SCIENCE

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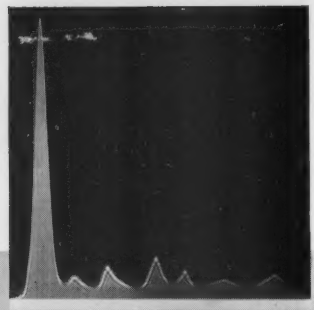
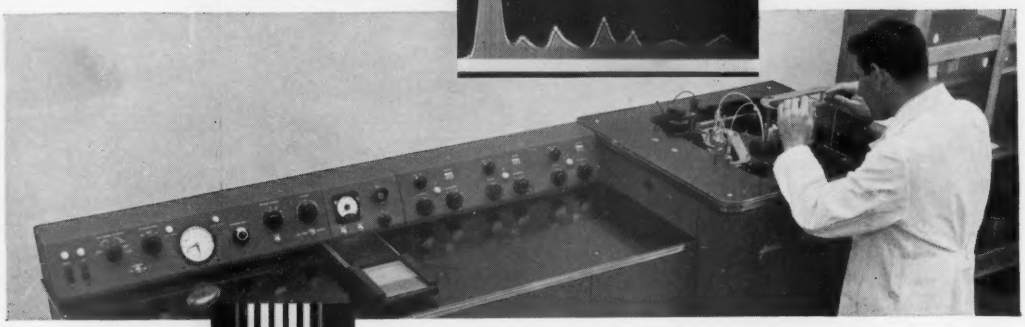
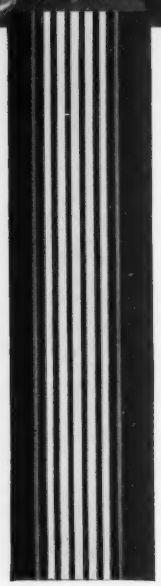
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



Electrophoresis of human serum diluted 1:6; ascending boundaries. Inclined knife-edge schlieren and Rayleigh fringes.





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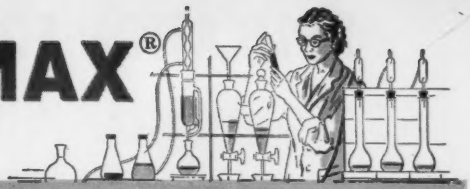

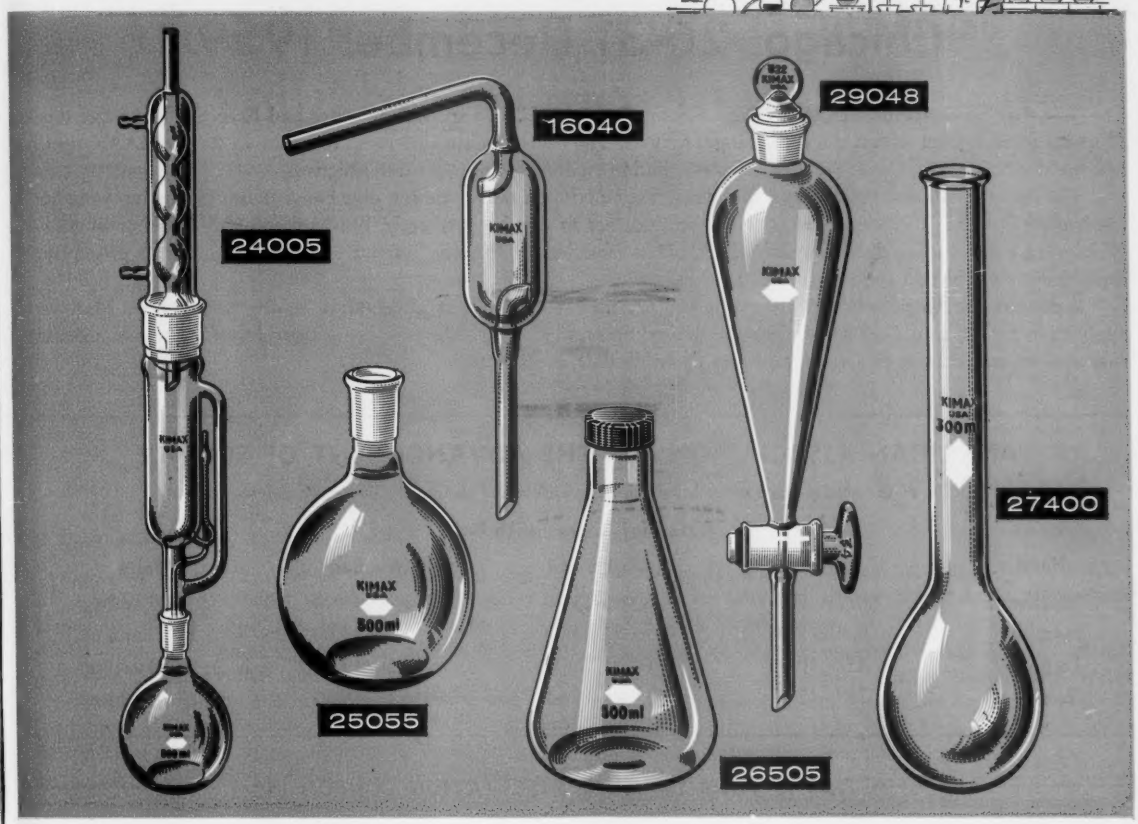

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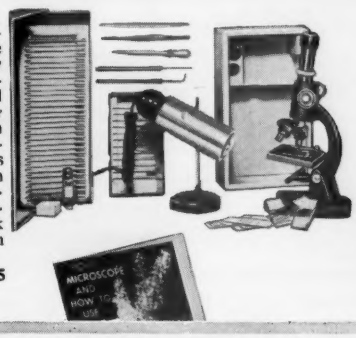

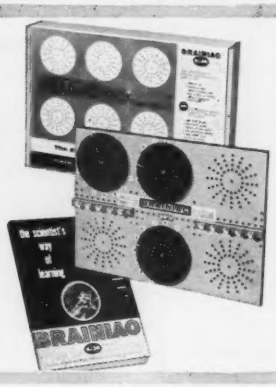

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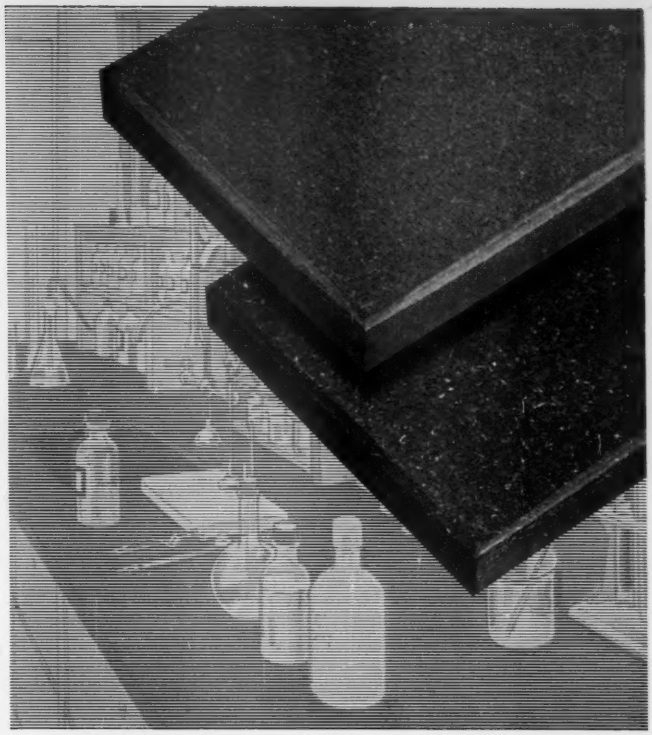

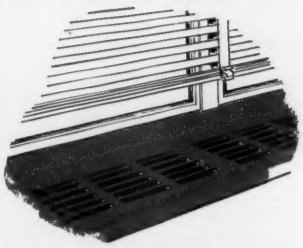

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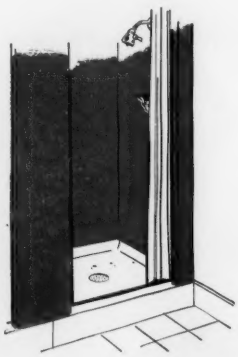

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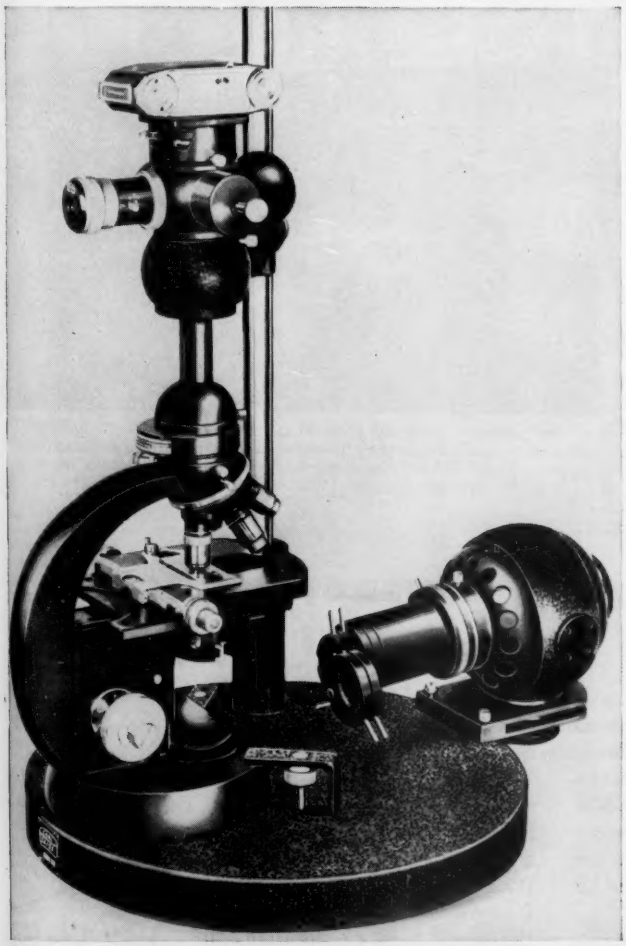

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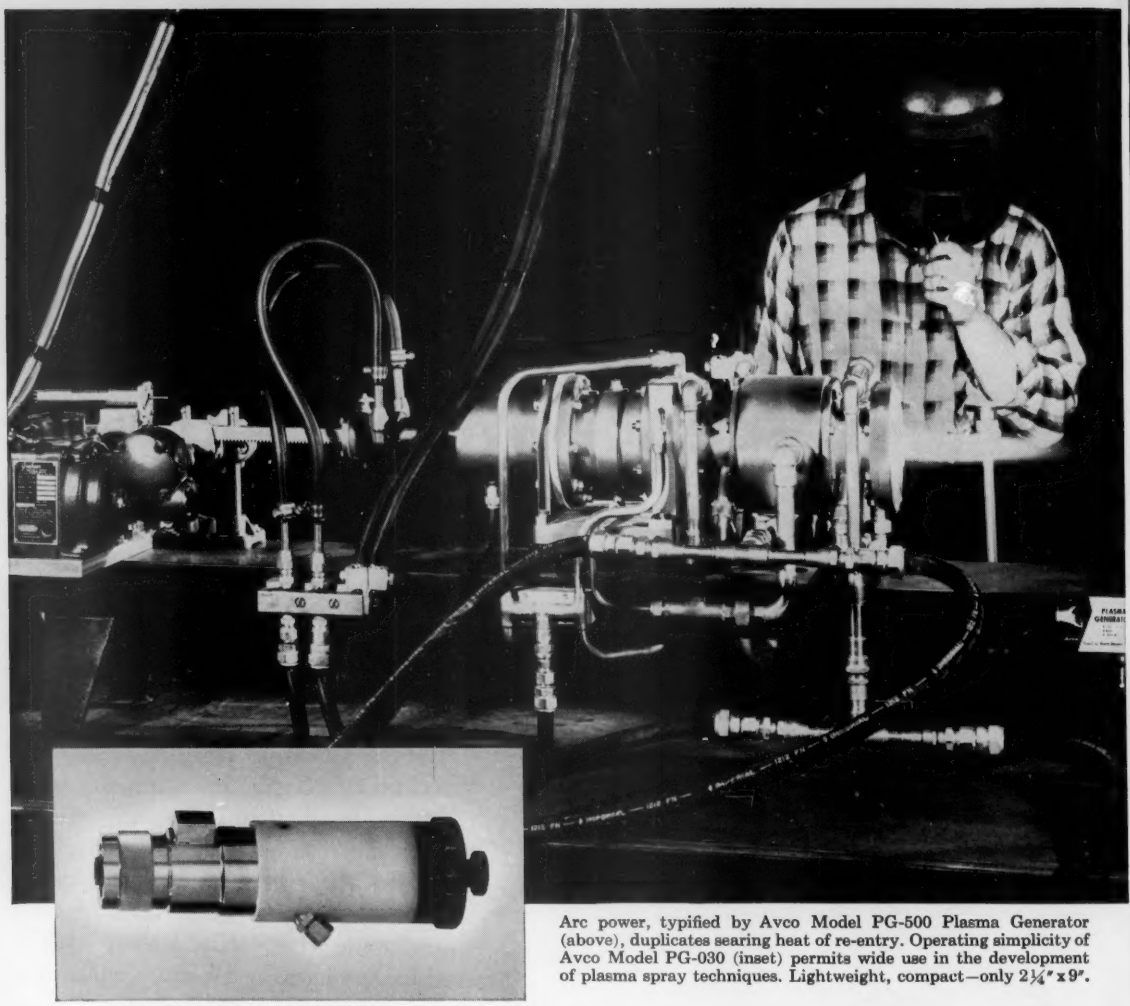

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SCIENCE

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Fission in the AEC

During the past few years, the feeling has been growing in and out of government that it is unwise to continue centering responsibility for protecting the nation against radiation hazards in the same agency that is responsible for developing nuclear weapons and reactors. Various criticisms of the Atomic Energy Commission's public safety program have been voiced, but the chief argument for a change is an appeal to the principle that regulatory and developmental functions should not be placed in the same hands. The interest in change has now reached critical size.

On 22 August the President assigned to the Department of Health, Education, and Welfare "primary responsibility" within the executive branch for the public health aspects of atomic energy. On the same date, the President designated the secretary of HEW as current chairman of the Federal Radiation Council, a unit he had created eight days earlier to help coordinate existing government programs in radiation research. And on the earlier date the President also gave his approval to legislation that if enacted will transfer from the AEC to the states certain safety tasks, with responsibility for federal assistance to the states to go eventually to HEW.

The story of these new developments is a story of advisory committees. A proposal to give the primary role in radiation protection to a group in HEW was made public last March in a report to the surgeon general by a special committee of scientists, the National Advisory Committee on Radiation. A few days later, to obtain advice for himself on questions of radiation control, the President set up a committee consisting of the chairman of the AEC, the secretary of HEW, and the director of the Bureau of the Budget. It was on the basis of recommendations by the latter group that the President gave new responsibilities to HEW and established the Federal Radiation Council. The members of the council are the heads of agencies most significantly involved with radiation, which means again the chairman of the AEC and the secretary of HEW and, in addition, the secretaries of Defense and Commerce. Besides its other tasks, the council will advise the President on public health aspects of radiation, while to advise *it* the council will have the services of the President's special assistant for science and technology.

The scope of HEW's new activities is indicated by the department's plans to increase expenditures in this area in the Public Health Service and Food and Drug Administration from about $1 million for fiscal 1959 to $3.2 million for fiscal 1960, with the possibility of asking Congress for additional funds in January. Spending in the AEC for fiscal 1960 is estimated at $3.5 million for fallout sampling and analysis and $21 million for research in radiation biology. HEW's principal new task is the regular receipt of radiation data from other government agencies and the interpretation of these data for the President and the public.

The present effort to place primary responsibility for radiation protection outside the AEC without unduly disturbing existing research and safety programs looks like a workable solution to a difficult problem. Many organizational details still have to be filled in, however. For example, the principal body up till now for recommending radiation protection standards to federal agencies has been a private but quasi-official group, the National Committee on Radiation Protection. How this advisory body will fit into the new scheme of things is one of the first questions the new Fededal Radiation Council must decide.—J.T.

11 September 1959, Volume 130, Number 3376 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Superconductivity: A Solved Problem?

Modern theoretical physics has come close to explaining this hitherto baffling phenomenon.

H. W. Lewis

In the first quarter of the 20th century, there was no shortage of phenomena of low-energy atomic, molecular, or solid-state physics which defied rational explanation in terms of the physical theories of the time. To be sure, a major breakthrough had occurred with the explanation of the spectrum of the hydrogen atom in terms of the old quantum theory, but efforts to extend this theory to systems involving more than one electron met with only limited success.

This situation changed dramatically in the middle and late 1920's with the development and exploitation of wave-mechanics, and problem after problem fell before the magnificent new theory. Indeed, it was soon apparent that there was no phenomenon in the area of atomic and molecular physics which would not be correctly explained by the new quantum mechanics, were we only able to solve the relevant equations. This was, of course, no small matter, but as the approximations improved, the agreement with experiment improved, and there was no substantial body of opinion which doubted that we were, at last, dealing with the correct theory.

Against this background of success, however, there stood, more and more isolated, two gross macroscopic phenomena that defied even qualitative understanding, although one was sure that they must be explicable in terms of quantum mechanics. These were superfluidity of helium, and superconductivity. Each represented an abrupt change in the flow or transport properties of matter at extremely low temperatures: in the case of helium, the complete disappearance of viscosity at about 2 degrees of absolute temperature, and in the case of superconductivity, the complete disappearance of electrical resistance in a large number of materials at temperatures ranging from a fraction of a degree up to 18 degrees absolute. Eighteen degrees, for an intermetallic compound of niobium and tin, is now the highest known superconducting transition temperature. We will omit here further reference to the problem of superfluidity, although great progress has also been made during the past few years toward an understanding of this problem.

Properties of Superconductors and Metals

What, then, are the properties of superconductors, and what do we have to understand? The principal properties of a superconductor are that, below its transition temperature, it offers no resistance to the flow of electrical current (circulating currents in a superconducting ring continue without observable decay for as long as it has been possible to keep the samples cold), and that it behaves as a perfect diamagnet—that is, it excludes magnetic fields from its interior. Both of these properties can be destroyed by the application of a sufficiently strong magnetic field, the critical field, and the critical field is itself a function of temperature, varying from zero at the transition temperature to a maximum at absolute zero. Some believe that the diamagnetism is a more fundamental property of a superconductor than its lack of resistance, but, in fact, a theory of superconductivity must account for both phenomena.

To see why there is difficulty in explaining the absence of resistance in some metals, it is, of course, necessary to begin by asking why metals exhibit electrical resistance in the first place. Electric currents in metals are carried by electrons, which, in a perfect crystal, would be able to pass unhindered through the body of the crystal, without resistance. Resistance appears only when the electrons are impeded or scattered in their progress through the crystal, and there are two main sources of such scattering.

In the first place, the crystal may not be perfect. Such imperfections may involve granular structure, dislocations of various sorts, or impurities in the metal, all of which can serve as scattering centers and can lead to electrical resistance. Such structural defects are normally independent of temperature and are responsible for the resistance of most materials at absolute zero.

The second main source of resistance is somewhat more esoteric, but, as we shall see, more closely connected with superconductivity. This is the emission and absorption of sound waves by the electrons. This is a necessarily elegant way of saying that the atoms in a solid metal are always involved in thermal agitation, and that this thermal agitation

The author is on the staff of the department of physics, University of Wisconsin, Madison.

also destroys the perfect periodicity of the crystal, leading to scattering of the electrons, hence to electrical resistance. The quantum-mechanical version of this statement is that the ordered motion of the atoms in a solid is called a sound wave, that any irregular motion of the atoms can be described in terms of these sound waves, and that an electron which is scattered by these irregular motions exchanges energy with the sound waves. Thus, we say that the electron has emitted or absorbed a sound wave in much the same way that electrons can emit or absorb light. Since the amount of thermal agitation of the atoms in a metal is dependent on the temperature, this part of the resistance is expected to be temperature-dependent. In particular, it should vanish at absolute zero, leaving only the impurity and defect resistance. The remarkable fact about superconductors is that *all* the resistance vanishes at a finite temperature, different from absolute zero. Thus, in particular, although nothing happens to the impurities, they cease, for some reason, to be able to scatter the electrons. The explanation of this extraordinary immobilization of the scattering centers is one of the major problems of the theory. The other is to connect this property, somehow, with the unwillingness of the metal to harbor a magnetic field—its property of perfect diamagnetism, otherwise known as the Meissner effect. There have been many abortive attempts to solve these problems. We will only consider here the modern developments, which began about 1950.

Experimentally, it is not known, and can never be known, whether all metals become superconductors at a sufficiently low temperature. All that can be said is that, at the lowest temperatures obtainable, some metals are, and some are not, superconducting. With this qualification, it had been known for a long time that there seemed to be an inverse correlation between a metal's conductivity at ordinary temperatures and its tendency to become a superconductor at very low temperatures. The very good conductors, like silver, copper, and gold, do not become superconductors, while the bad ones, like lead and tin, are superconducting at quite high temperatures. However, if one made a metal into a bad conductor, by, for example, adding impurities, this did not appreciably affect its superconducting properties. Thus, the correlation appeared to be with that part of the resistivity due to the phonon or sound-wave interaction.

Isotope Effect

With this background, the stage was set for the development of a theory of superconductivity, but still no substantial progress was made until 1950, when the great breakthrough occurred. In this year, both experimental confirmation that superconductivity was connected with the phonon interactions and the rudimentary beginnings of a theoretical explanation were achieved.

The former was accomplished by the discovery of the isotope effect—that the superconducting transition temperature of a material depended upon its isotopic constitution, with the heavier isotopes exhibiting lower transition temperatures. This is a most remarkable result, and it is important to understand just what it means, independently of any detailed theory of superconductivity. As we know, a high temperature is characterized by a great deal of agitation of the atoms of a material, and a low temperature, by the fact that the atoms are nearly quiescent. Further, at a given temperature, heavier atoms (or isotopes) are considerably less agitated than the lighter atoms, because it takes more energy to agitate a heavy atom. Indeed, at the very low temperatures characteristic of superconductivity, the atomic thermal agitation has practically ceased. This means that, at very low temperatures, one would not expect the mass of an atom to be important, since the mass affects only the thermal agitation and the latter has practically disappeared. Thus, one's first guess is that superconductivity cannot depend upon the atomic mass. Yet, the isotope effect is evidence that it does, and in a very substantial way. This can only mean that superconductivity depends upon the interaction of the electrons in the metal with the sound waves, and in a way which does not depend upon the thermal agitation of the atoms, or upon thermal excitation of the sound waves. Indeed, since the superconductivity disappears at a sufficiently high temperature, one can conclude that thermal effects are antipathetic to superconductivity.

Phonon-Electron Interaction

What, then, are the possible consequences of an interaction between electrons and phonons that could conceivably lead to a theory of the superconducting phenomenon? Only two pass the test of being thermally independent, or, more specifically, available at absolute zero. Historically, the first to be thought of, in 1950, was the self-energy effect. This is exactly analogous to the corresponding electromagnetic self-energy of an electron, which is, perhaps, more familiar. The latter arises in the following way: We know that the electron acquires energy when it is placed in an electric field, and we know further that an electron serves, like any other charged particle, as the source of an electric field. The energy the electron has by virtue of being inescapably in the field of which it is itself the source is called the self-energy. Similarly, the electron in a metal produces a local phonon field, with which it interacts. The latter may be more easily understandable as a local distortion of the metallic lattice, due to the presence of the electron.

But how can this lead to an effective interaction between electrons, which is what one needs for a theory of superconductivity? The answer to this follows from the observation that electrons are indistinguishable from each other, so that an interaction of an electron with itself inevitably leads to an apparent interaction with other electrons. It was this apparent interaction which served as the basis for both Fröhlich's and Bardeen's 1950 theories of superconductivity. These theories were found wanting because of technical difficulties in their formulation, which we will not go into here, and also because it was never found possible to bridge the gap between the apparent interaction and the phenomenology of superconductors. In short, the self-energy effects led to a theory of something, but that something could never be identified with superconductivity. It is now felt by some that such effects may indeed be appreciable, but that they do not, in fact, distinguish between superconductors and nonsuperconductors.

Electron-Electron Interaction

The next step is, then, to explore the higher-order effects of the interaction between electrons and phonons, and this was done by Bardeen and his collaborators in 1957. This appears to have led to a reasonable picture of the superconducting state, though, at this writing, there is still considerable controversy about the detailed formulation of the theory—controversy which is by no means trivial.

The basic difference between this

theory and theories of the self-energy type can again be most easily understood in terms of the electromagnetic analogy. Again the electron serves as the source of an electromagnetic field, but this time the energy arises from the presence of another electron in the field. Such a description applies to the origin of electric and magnetic forces between electrons, and the analogous effect in metals leads to a phonon-induced interaction between electrons. One electron distorts the metallic lattice, and the other electron is affected by the distortion. Note that the dynamic effects of such an interaction depend upon the isotopic mass of the metal atoms, as they should, so that it is conceivable that the isotope effect can be explained by such a theory.

At first sight it might appear, from what has been said earlier about the fundamental indistinguishability of electrons, that the two interactions we have described—of an electron with itself and with another electron—are really the same. It is in fact true that the distinction between them is a matter of convenience and is more a matter of different methods of calculation than of different theories. In the end, what is hoped for is a theory of a many-electron system in a metal, in interaction with the phonons of the lattice, and such a theory must incorporate all the phenomena involved. Nonetheless, it is possible to start writing down theories with different areas of emphasis, and, as each is refined, they should tend to reveal the common truth. This is a situation not solely characteristic of the theory of superconductivity.

The most important single feature of this electron-electron interaction is that it induces transitions between degenerate states—that is, between states which have the same energy. To see this, consider a pair of electrons that have equal and opposite momenta, so that the total momentum of the state under consideration is zero. When these electrons scatter each other (because of the phonon-induced interaction) the conservation of momentum tells us they will still have equal and opposite momenta, though in different directions, and the conservation of energy tells us that the momentum of each will have the same magnitude as before the scattering. Hence, their directions of motion will simply have been rotated through a certain angle, and their state will have been transformed into another equivalent state. Note that this is only necessarily true if they start with equal and opposite momenta.

Now it is a fact that if, in a quantum-mechanical calculation, a variety of degenerate states are present, and transitions are induced between them by the forces present in the problem, then all these states must be treated together in determining the state of the system. The problem is not trivial in the case of the phonon interaction, but this can, to a certain extent, be accomplished. We will make no effort here to go into the mathematical details, but only to describe those physical consequences of the theory, on which most of the active workers in the field are agreed.

The upshot of the treatment is that the ground state of the metal is not quiescent but involves large numbers of excited electron pairs (equal-and-opposite-momenta pairs, as described above), interacting with each other through the electron-phonon interaction. Thus, each pair is continually being scattered and rescattered into the other available pair states, and the ground state is a seething mass of such pairs.

The recognition that such a state, so dramatically different from the ground state of a nonsuperconductor, can be formed is half the battle. The other half is to show that a metal in such a state exhibits the well-known properties of a superconductor, and it is here that there still exist some ambiguities in the theory. Once one has settled on the ground state described above, it is necessary, in order to determine the further properties of the material, to learn something about the spectrum of excited states. The only predictions one can make on the basis of the ground state alone are the identity of the superconducting metals and, via a thermodynamic argument, the critical magnetic field at absolute zero. Both of these predictions seem to agree tolerably well with experiment, and from the latter there emerges the isotope effect, as observed.

The Energy Gap

The basic feature of the spectrum of excited states, which leads to the characteristic superconducting properties, is the energy gap. By this we mean that it takes a finite amount of energy to excite the lowest-lying excited state above the ground state. This is a prediction of the theory, as well as a prediction that this energy gap should be a function of temperature, largest at absolute zero and decreasing to zero as the temperature is increased to the transition temperature at zero field. It is not easy to see why the energy gap should lead to perfect diamagnetism or to perfect conductivity, so let us first concern ourselves with the question of whether the gap exists. The most direct evidence that it does arises from experiments on the absorption of electromagnetic radiation in superconductors. In these experiments, a superconductor is exposed to radiation of a given frequency, and the amount of radiation absorbed by the superconductor is measured. It is found that, roughly speaking, only radiation above a given frequency is absorbed. This is exactly what one expects from an energy-gap model, where there is a minimum energy of excitation of the electrons, since the energy of a photon is connected to its frequency by Planck's constant. Indeed, there is even some recent evidence that the energy gap may vary with temperature, as expected. There are other types of evidence, such as the specific heat, and, all in all, we are quite sure that the energy gap exists. But why does it lead to the properties of a superconductor?

It was pointed out long ago by London that, if the wave functions of the electrons were, for some reason, unusually rigid, this might account for the diamagnetism of a superconductor. What has been shown by Bardeen and his collaborators is that the energy gap induces a peculiar stability in the electronic wave functions, so that the conditions for perfect diamagnetism are, in fact, fulfilled. We will not go into the many details of this argument here.

In summary we can say that the many successes of this physically simple, but mathematically still obscure, theory leave no doubt that a major success has been scored in the quest for a theory of superconductivity. While there are a number of questions still to be resolved, it is clear to everyone in the field that we stand, for the first time, within reach of a real understanding of this heretofore baffling problem.

Potential Productivity of the Sea

Organic production by marine plankton algae is comparable to agricultural yields on land.

John H. Ryther

Under ideal conditions for photosynthesis and growth, what is the maximum potential rate of production of organic matter in the sea? Is this potential ever realized, or even approached? How does the sea compare with the land in this respect? These questions may be approached empirically with some measure of success but, aside from the time and effort required by this method, one can never be certain how close to the optimum a given environment may be and, hence, to what extent the biotic potential is realized.

However, we do know with some degree of certainty the maximum photosynthetic efficiency of plants under carefully controlled laboratory conditions; and there is a considerable literature concerning the effects of various environmental conditions on photosynthesis, respiration, and growth, particularly with respect to the unicellular algae. From such information it should be possible to estimate photosynthetic efficiencies and, for given amounts of solar radiation, organic production under natural conditions. This indirect and theoretical approach cannot be expected to provide exact values, but it does furnish a supplement to the empirically derived data which may help substantiate our concepts both of the environmental physiology of the plankton algae and the level of organic production in the sea.

An attempt has been made to use this joint approach for the marine environment in the following discussion. The only variable considered is light, and the assumption is made that virtually all of the light which enters the water (and remains) is absorbed by plants. Such situations are closely approximated in plankton blooms, dense stands of benthic algae, eelgrass, and other plants. For the rest, it is assumed that temperature, nutrients, and other factors are optimal, or at least as favorable as occur under ideal culture conditions. Given these conditions, I have attempted to calculate the organic yields which might be expected within the range of solar radiation incident to most of the earth. These data are then compared with maximal and mean observed values in the marine environment and elsewhere, and an attempt is made to explain discrepancies.

The calculations which appear below are based, for the most part, upon experimentally derived relationships between unicellular algae and the environment, and are therefore applicable only to this group. This must be kept in mind when, later in the discussion, comparisons are drawn between the theoretical yields and observed values of production by larger aquatic and terrestrial plants.

The values for the efficiency of photosynthesis under natural conditions are based on the utilization of the visible portion of the solar spectrum only (400 to 700 mμ), or roughly half of the total incident radiation. In converting these efficiencies to organic yields, it is assumed that the heat of combustion of the dry plant material is 5.5 kcal per gram, which closely approximates values for unicellular algae reported by Krogh and Berg (*1*), Ketchum and Redfield (*2*), Kok (*3*), Aach (*4*), Wassink *et al.* (*5*), and others.

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Reflection and Backscattering

Of the sunlight which strikes the surface of the ocean, a certain fraction is reflected from its surface and never enters the water. The remainder penetrates to depths which depend upon the concentration of absorbing and scattering particles or dissolved colored substances. While scattering may be as important as absorption in the vertical attenuation of the light, it makes little difference as far as the biological utilization of the radiation is concerned, since the scattered light is eventually absorbed, with the exception of a small fraction which is backscattered up out of the water. The combined reflected and backscattered light is lost to the aquatic system; the rest remains in the water, where, under the ideal conditions postulated, it is absorbed entirely by plants.

The fraction of the incident radiation which is reflected and backscattered has been studied by Powell and Clarke (*6*), Utterback and Jorgenson (*7*), and Hulburt (*8*). The two factors have been treated separately, but they may be considered together here. Their combined effect is rather small, ranging from about 3 to 6 percent, depending somewhat upon who made the measurements and the conditions under which the measurements were made. The highest values were observed when the sky was overcast. Sea states, ranging from flat calm to whitecap conditions, made surprisingly little difference. Reflection and backscattering were also found by Hulburt to be independent of the sun's angle, despite the fact that reflection increases greatly with the angle (from the zenith) of the incident light, particularly at angles above 60°. The explanation for this apparent contradiction lies in the fact that as the sun approaches the horizon, indirect sky light becomes increasingly important, and it eventually exceeds the intensities of the sun itself.

Hulburt's data also indicate that backscattering is not greatly influenced by the amount of particulate matter in the water, since his values in the clear Gulf Stream did not differ appreciably from those made in the turbid waters of Chesapeake Bay.

For the calculations which are made here, it is considered that an average of 5 percent of the incident radiation is lost through the combined effects of reflection and backscattering.

Photosynthesis and the Visible Spectrum

We first consider the efficiency of photosynthesis in sunlight at levels below the saturation intensity. Within this range, photosynthesis is directly proportional to the light intensity (or very nearly so), and the efficiency is therefore constant.

Despite the vast numbers of studies of quantum yield (that is, photosynthetic efficiency) in the literature, few data are available for the entire visible spectrum. Figure 1*A* shows two such series of measurements, one with the green alga *Chlorella* (Emerson and Lewis, *9*), the other with the diatom *Navicula minima* (Tanada, *10*). The ordinate is expressed as quantum requirement (the number of quanta required to reduce 1 mole of CO_2) rather than a reciprocal, quantum yield (moles of CO_2 reduced per quantum) as shown originally by the authors. Although the two organisms have strikingly different pigment complements, the curves are surprisingly similar, with minimal requirements in the red and yellow parts of the spectrum, maximal in the blue-green. *Navicula* appears to be somewhat more efficient than *Chlorella,* but the differences may not be significant.

Figure 1*B* illustrates the fact that the energy per quantum between 400 and 700 mμ decreases from a maximum of 71 kcal per mole quanta of blue light to 41 cal per mole quanta of red light. The heat of combustion of one reduced mole of CO_2 (reduced to CH_2O) is 112 kcal. A quantum requirement of 10 therefore represents an efficiency of $112/(41 \times 10) = 27.3$ percent in red light and $112/(71 \times 10) = 15.7$ percent in blue light. Figure 1*C* shows the efficiencies of *Chlorella* and *Navicula* throughout the visible solar spectrum.

The spectral distribution of daylight varies with solar altitude and with the water vapor, carbon dioxide, and dust content of the atmosphere. Figure 2 shows the spectral distribution of daylight under average atmospheric conditions and with an air mass of 2 (solar angle = 30° from zenith) as given by Moon (*11*).

If the curves in Fig. 1*C* are averaged and the mean efficiency for the entire visible spectrum is calculated, weighing the mean for the average spectral distribution of sunlight as given in Fig. 2, this value turns out to be 18.4 percent. Taking into consideration a 5-percent reflection and backscattering loss, the efficiency of photosynthetic utilization of visible sunlight *below saturation intensity* incident to the water surface is 17.5 percent.

In extremely turbid waters and in those containing organic stains (the "yellow substance" described by Kalle, *12*), blue and green light may be selec-

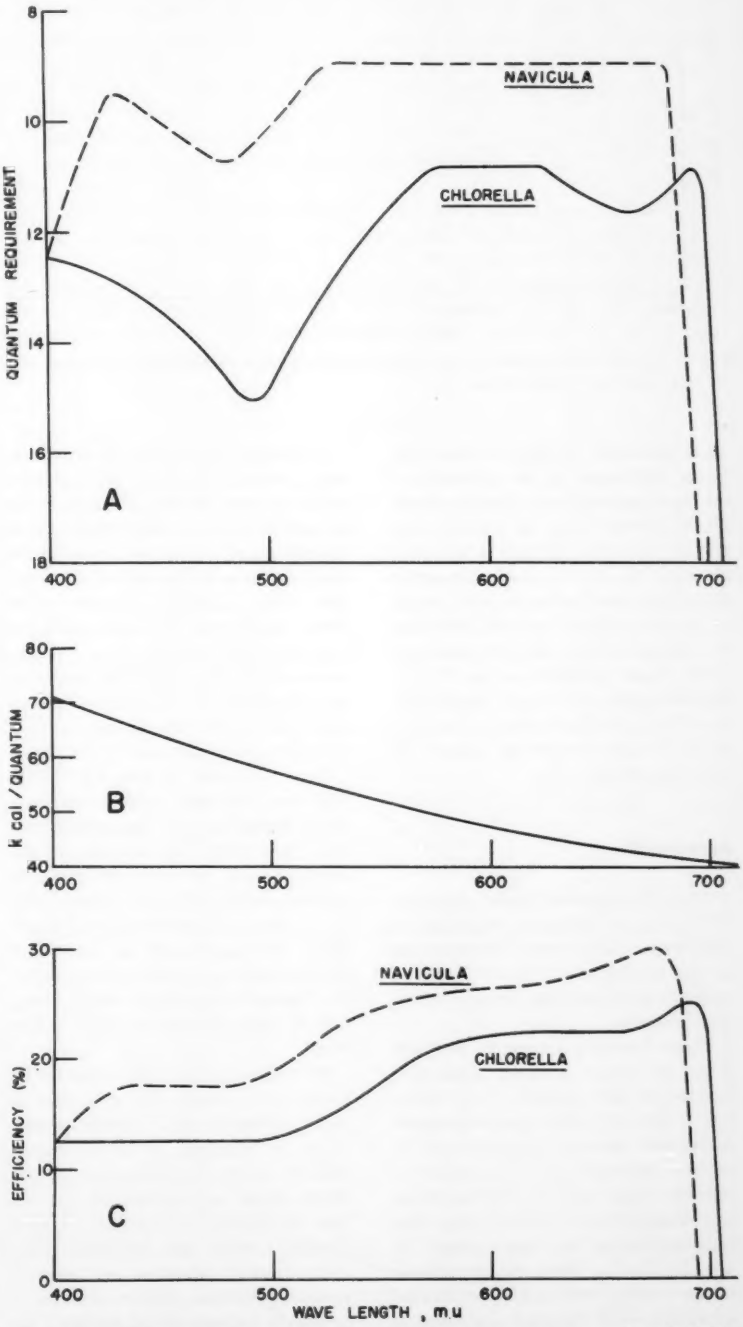

Fig. 1. (*A*) Quantum requirement of photosynthesis as a function of wavelength of light for *Chlorella* [after Emerson and Lewis, *9*] and for *Navicula* [after Tanada, *10*]. (*B*) Energy per mole quantum of light as a function of wavelength. (*C*) Efficiency of photosynthesis as a function of wavelength, calculated from (*A*) and (*B*).

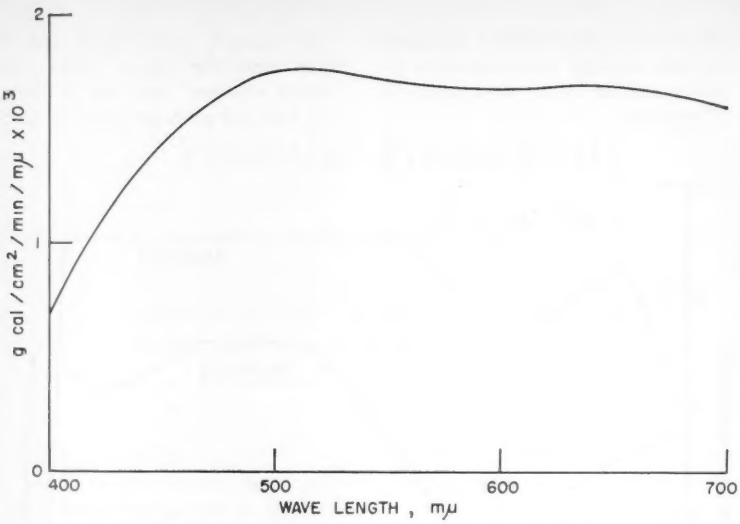

Fig. 2. The spectral distribution of daylight under average atmospheric conditions with air mass equal to 2. [After Moon, *11*]

tively absorbed, resulting in somewhat higher efficiencies in the utilization of the light penetrating to greater depths. On the other hand, in normal, clear oceanic water the red light is selectively absorbed by the water and blue-green light penetrates to the greatest depths, where it is used still less effectively than the average incident daylight considered above. These modifications are not considered in this article, since we are dealing with an idealized situation in which all of the light entering the water is absorbed by plants.

Intensity Effect

Above the saturation point, photosynthesis does not increase in proportion to light intensity, but remains constant or, at high intensities, is actually depressed, owing to photooxidation or other inhibitory processes.

Figure 3*A* shows a curve of photosynthesis by marine plankton algae as a function of light intensity, from Ryther (*13*). This is a mean curve of experiments with cultures of 14 species of organisms, preconditioned to a variety of different light regimes. Photosynthesis was measured by C^{14} uptake under solar radiation during the 4-hour period (10 A.M. to 2 P.M.) when the intensity is nearly constant and maximum. Graded intensities were obtained with neutral density filters. Almost identical curves were obtained by Steemann Nielsen and Jensen (*14*) for natural plankton populations.

Photosynthetic efficiencies remain constant, or nearly so, up to the saturation point, but then decline sharply at higher intensities. This decrease is illustrated by the difference between the actual photosynthesis curve in Fig. 3*A* and the dotted line, which is an extrapolation of the linear portion of the solid curve and represents photosynthesis if the efficiency remained constant. Figure 3*B* shows relative efficiencies as a function of light intensity, obtained from the ratio between the solid and dotted lines in Fig. 3*A*.

Using the data in Fig. 3*A*, Ryther (*13*) has calculated relative photosynthesis throughout the day and at various depths within the euphotic (illuminated) zone of the ocean for days with different values for total incident radiation. Several curves were thereby produced showing values for total daily photosynthesis at several depths within the euphotic zone relative to the hourly rate of photosynthesis at light saturation.

On extremely dull days, when the intensity never reaches the saturation region, photosynthesis is directly proportional to light intensity at all depths, and the curve of photosynthesis with depth shows an exponential decrease from the surface, as does that of light. On bright, sunny days, intensities at the surface exceed saturation and normally produce inhibition (which occurs at ⅓ or less the intensity of full sunlight). On such days, photosynthesis at the surface is less than that at intermediate depths. In all cases, photosynthesis at depths where the surface light is reduced to 10 percent or less is directly proportional to intensity, and in this region it decreases exponentially, following the light curve.

By extrapolating the lower, exponential portion of the photosynthesis curve to the surface, one may create a hypothetical curve of photosynthesis if the latter maintained the same efficiency at all depths. The ratio of the actual photosynthesis curve to this hypothetical exponential curve will then show the reduction in efficiency caused by light intensities above saturation in the upper waters. This has been done in Fig. 4 for a series of photosynthesis curves on days of varying incident radiation. Since photosynthesis at the various depths is a function of light intensity and not of depth per se, the units on the ordinate of Fig. 4 are natural logarithms of I_0/I and thus represent the depths to which given fractions of the incident radiation penetrate. The curve for the day with lowest radiation (20 gcal/cm² day) is exponential all the way to the surface, indicating that on such a day there is no reduction in photosynthetic efficiency from the effects of light intensity. On days of progressively higher light intensity, the photosynthesis curve departs more and more from the exponential curve illustrating the increasing reduction in efficiency.

If it is assumed that the maximum efficiency (with no intensity effect) is 17.5 percent, as calculated in the previous section, Fig. 5 shows the cumulative intensity effect with efficiencies plotted as a function of total daily incident radiation. The points were obtained from Fig. 4 from the ratio of the actual photosynthesis curves for each value of radiation to the exponential curve of maximum (17.5 percent efficiency. It may be seen that efficiencies decrease from 17.5 percent at low intensities to 6.5 percent on a day when 600 g cal/cm² reaches the earth's surface. It is noteworthy that the efficiency curve does not decrease in a regular way with increasing intensities, but that the rate of decrease becomes less at higher intensities. This is due to the fact that higher values of daily radiation are caused not only by higher intensities of sunlight but to an even greater extent by longer days including more hours of low intensity light.

We are now ready to calculate photosynthesis for different values of incident radiation from the efficiency curve shown in Fig. 5. This is done by multiplying the efficiency by one-half the appropriate values of radiation (that por-

tion of the solar spectrum available for photosynthesis). This gives the amount of energy fixed in photosynthesis. Dividing this by 5.5 (the heat of combustion of a gram of average plant material, as discussed in the first section) we obtain a value which represents grams of organic matter produced per day beneath a square meter of water surface, provided that all the light entering this 1-meter-square column of water is effectively absorbed by plants. These values, shown as the upper broken line in Fig. 5, are equivalent to "real photosynthesis" or "gross production." They are hypothetical in the sense that they cannot be observed as a yield, since the plants must draw upon this organic matter to satisfy their own metabolic requirements. We must therefore subtract an amount of organic matter equivalent to the plants' respiration in order to calculate the amount of material available for harvest, the so-called "net production."

Respiratory Loss

Under conditions of active growth, photosynthesis at light saturation is some 10 to 20 times as great as dark respiration (see Ryther, *15*). Higher values have been reported, but it seems doubtful that they could represent steady-state conditions in natural populations. If we take a ratio of 15:1 as average for $P:R$ (photosynthesis:respiration) at optimal light, it is obvious that over a 24-hour period, half of which is dark, and within an entire plant community, of which many of the plants are in suboptimal light at all times, respiration must account for a much greater fraction of photosynthesis.

In calculating the ratio $P:R$ in natural communities, the oversimplified assumption will be made that respiration remains constant and independent of light and photosynthesis. While the literature pertaining to this subject is contradictory and in a state of great confusion (see, for example, Rabinowitch, *16*), there is mounting evidence that respiration and photosynthesis are not wholly independent processes. However, since there is no good quantitative formulation of a relationship between them which may be incorporated into our calculations, it must be neglected here.

As mentioned above, the data from Fig. 3*A* together with light intensity values for a group of days with varying total incident radiation have been used to calculate photosynthesis as a function of radiation. (See Ryther, *13*, for a full description of these calculations). The values given by this treatment represent photosynthesis per day beneath a square meter of surface relative to the value for photosynthesis per cubic meter per hour at light saturation. For example, a value of 100 would mean that daily photosynthesis beneath a 1-meter-square water column is 100 times as great as photosynthesis within a 1-cubic-meter aliquot of that water column for 1 hour at optimal light intensity (assuming that the plant population is evenly distributed within this water column).

Since respiration is 1/15 photosynthesis at light saturation and is also stipulated to be constant with respect to light, depth, and time of day, we may calculate total daily respiration in the same relative units as photosynthesis. The curves of photosynthesis and respiration as functions of radiation are shown in Fig. 6. They cross at 100 g cal/cm² × day, which may be considered the daily compensation level for an entire plant community. The value $(R/P) \times 100$ is the percentage of respiratory loss and is shown as the lower broken line in Fig. 6. It ranges from 100 percent at radiation values of 100 g cal/cm² day or less to 28 percent on extremely bright, long days.

Net Production

Returning to Fig. 5, gross production may be reduced by the respiratory loss (Fig. 6), giving the curve of net production, which begins at 100 g cal/cm² day and reaches a value of 25 g/m² day under radiation of 600 g cal/m² day (the lower broken line in Fig. 5).

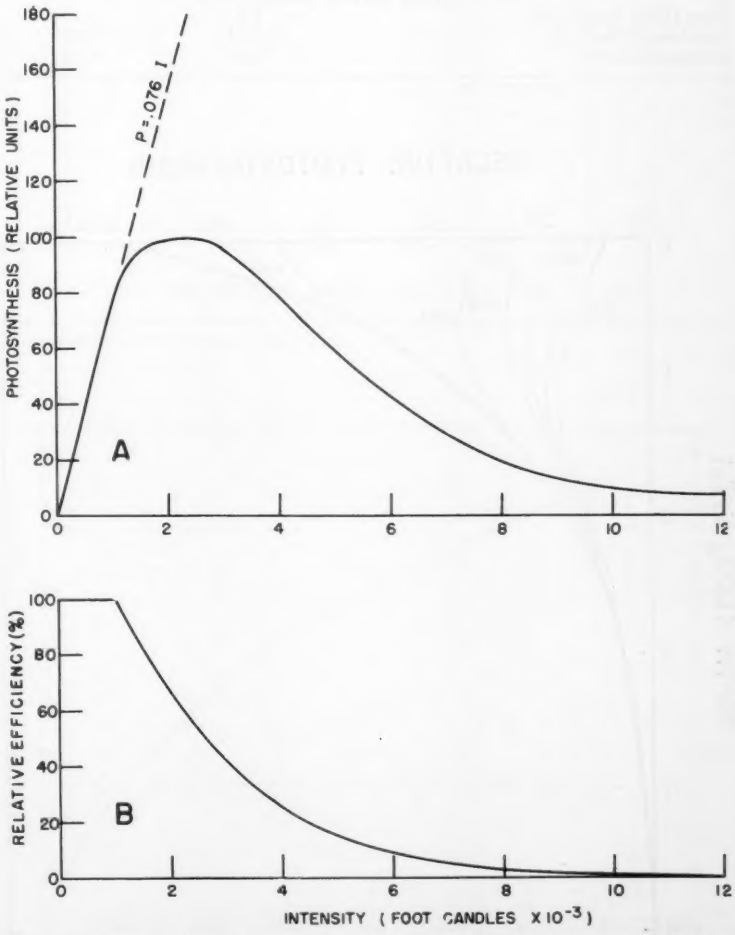

Fig. 3. (*A*) Photosynthesis of marine phytoplankton as a function of light intensity [after Ryther, *13*]. Broken line is the extrapolation of the linear portion of the solid line representing hypothetical sustained maximum photosynthetic efficiency. (*B*) Efficiency of photosynthesis as a function of light intensity, calculated from *A*.

Table 1. Gross and net organic production of various natural and cultivated systems in grams dry weight produced per square meter per day.

System	Gross	Net
A. Theoretical potential		
Average radiation (200 to 400 g cal/cm² day)	23–32	8–19
Maximum radiation (750 g cal/cm² day)	38	27
B. Mass outdoor Chlorella *culture (26)*		
Mean		12.4
Maximum		28.0
C. Land (maximum for entire growing seasons) (18)		
Sugar cane		18.4
Rice		9.1
Wheat		4.6
Spartina marsh		9.0
Pine forest (best growing years)		6.0
Tall prairie		3.0
Short prairie		0.5
Desert		0.2
D. Marine (maxima for single days)		
Coral reef (*27*)	24	(9.6)
Turtle grass flat (*28*)	20.5	(11.3)
Polluted estuary (*29*)	11.0	(8.0)
Grand Banks (Apr.) (*30*)	10.8	(6.5)
Walvis Bay (*23*)	7.6	
Continental Shelf (May) (*19*)	6.1	(3.7)
Sargasso Sea (Apr.) (*31*)	4.0	(2.8)
E. Marine (annual average)		
Long Island Sound (*32*)	2.1	0.9
Continental Shelf (*19*)	0.74	(0.40)
Sargasso Sea (*31*)	0.88	0.40

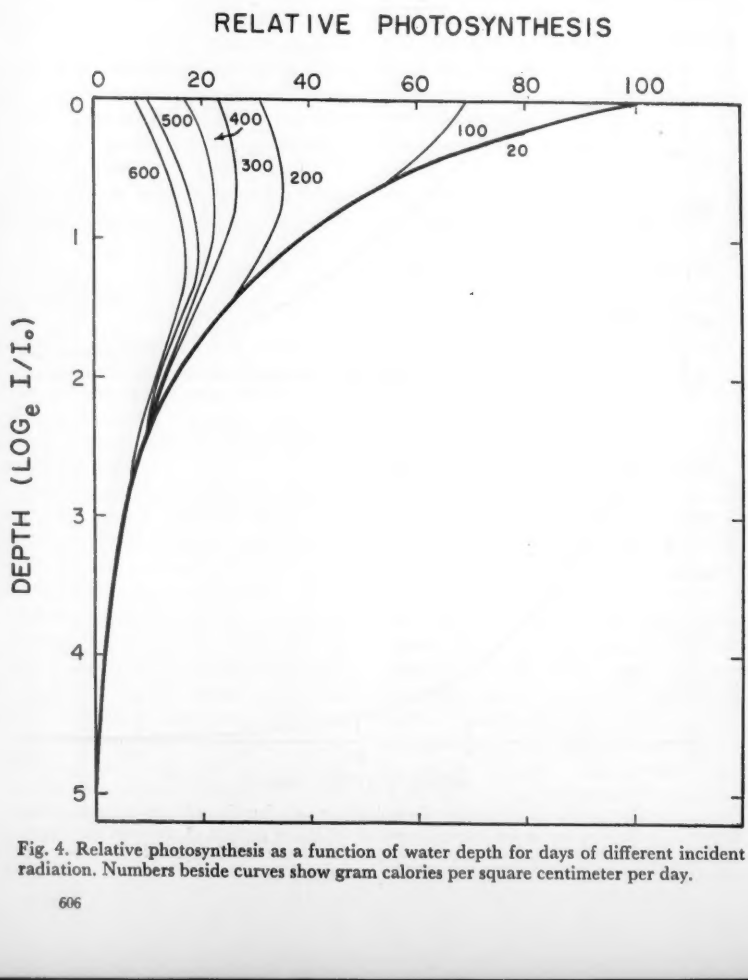

Fig. 4. Relative photosynthesis as a function of water depth for days of different incident radiation. Numbers beside curves show gram calories per square centimeter per day.

Although the annual range of daily incident radiation is extremely wide, even for a given latitude, this short-term variability is probably not very significant in affecting the general level of organic production of a given area. If one examines the tables compiled by Kimball (*17*) showing mean monthly radiation for different latitudes, it appears that over 80 percent of the data (including all latitudes and seasons) fall within a range of 200 to 400 g cal/cm² day. Thus, over most of the earth for most of the year a potential production of organic matter of some 10 to 20 g/m² day may be expected, while for shorter periods of fine summer weather, a net production of 25 g/m² day or slightly more may occur.

Comparison of Theoretical and Observed Production Rates

We may now compare the production rates which were calculated in the preceding sections with some values which have been observed empirically. Since the former are based on hypothetical situations in which all light entering the water is absorbed by plants, the observational data, to be comparable, must be restricted to natural environments in which these conditions are at least closely approximated (for example, in dense plankton blooms, thick stands of benthic algae and rooted plants). In addition to these maximal values, the theoretical potential may be contrasted with average oceanic productivity rates.

We may also extend this comparison to the terrestrial environment, including some of the better agricultural yields, bearing in mind, however, that the physiology and hence, perhaps, the biotic potential of land plants may differ significantly from those of algae.

Finally, we may include the yields of *Chlorella* grown in outdoor mass culture, drawing here upon the excellent, continuing studies of H. Tamiya and his collaborators. These are of particular interest, since the conditions of these experiments were as optimal as possible and since the physiology of *Chlorella* is identical or closely similar to that of the organisms upon which our calculations are based. Thus the *Chlorella* yields will serve as a check for the theoretical production rates.

It is important, in making these comparisons, to keep in mind the distinction between gross and net production as defined above. Some of the data refer to true photosynthesis measurements (gross

production) while others, such as the *Chlorella* experiments and the agricultural yields, are based on the actual harvest of organic matter (net production). In those cases in which only gross production values are available and where radiation data are given, net production has been obtained from Figure 5 and is shown in parentheses.

The theoretical production potential for average and maximal radiation, and the observational data for both marine and terrestrial environments, are given in Table 1. In each case the original source is given, except for the land values, where reference is made to the recent compilation by Odum (*18*). The various methods by which the values were obtained will not be discussed here except in the case of the unpublished data, in which gross production was calculated from chlorophyll and light, according to the method of Ryther and Yentsch (*19*) and net production was measured by the C^{14} method, uncorrected for respiration as this method is interpreted by Ryther (*20*). Where gross production (photosynthesis) was originally reported as oxygen evolution, this has been converted to carbon assimilation, using an assimilatory quotient

$$\left(\Delta \frac{+O_2}{-CO_2}\right)$$

of 1.25 (see Ryther, *20*). Carbon uptake, in turn, has been converted to total organic production by assuming that the latter is 50 percent carbon by weight.

The maximal values for the marine environment represent the seven highest such values known to me. In addition to these, data are given for three regions (one inshore, one coastal, and one offshore) which have been studied over long enough periods of time to justify the calculation of annual means.

Discussion

The mean yield of *Chlorella* obtained by the Japanese workers is almost identical to the mean theoretical production for days of average radiation (12.4 versus 13.5 g/m² day). These yields of *Chlorella* were produced only during the warmer part of the year, presumably owing to the poor growth of *Chlorella* at low temperatures. The highest yields of *Chlorella* (up to 28 g/m² day) were, according to Tamiya, "obtained on fair days in the warmer months." This maximum is approximately the same as the theoretical net production for days of maximum radiation. Thus, the *Chlorella* yields agree very well with the theoretical productive potential of the sea.

The land values for net production quoted from Odum's tables range from 18.4 g/m² day for the highest yields of sugar cane to 0.2 g/m² day for deserts. The best agricultural yields are generally of the same order of magnitude as the theoretical net production of the sea, as are the values for the salt marsh and the pine forest (during its years of best growth). Uncultivated grasslands range from 3.0 for tall prairie to 0.2 for desert

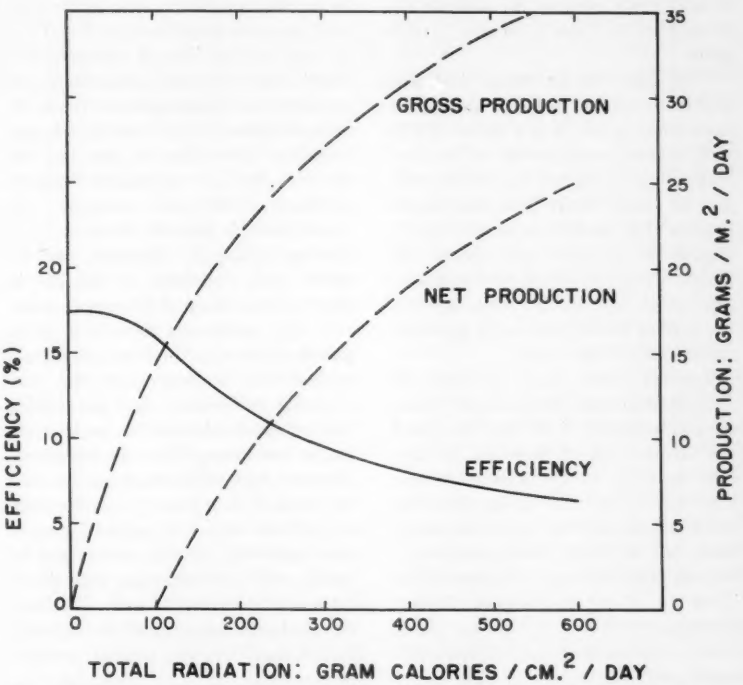

Fig. 5. Photosynthetic efficiency and theoretical maximum potential gross and net production as a function of incident radiation.

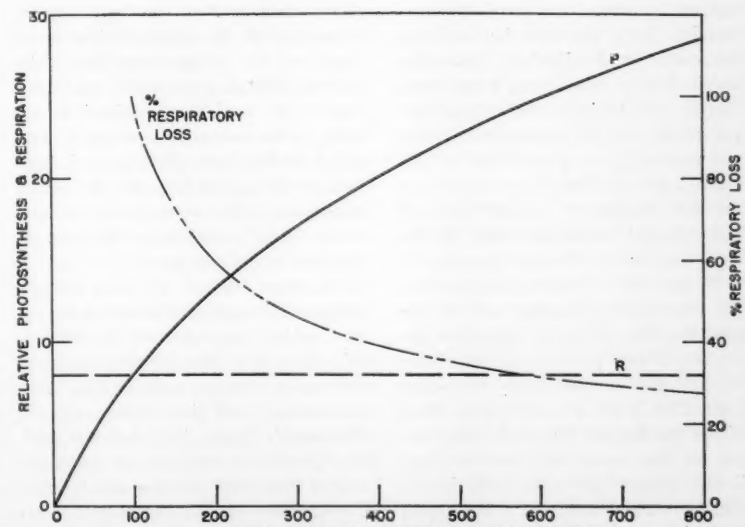

Fig. 6. Relative photosynthesis, respiration, and percentage of respiratory loss as a function of incident radiation.

conditions. Because of the extreme contrasts among terrestrial environments, mean values for the land as a whole are difficult to determine and would have little meaning. It is interesting, however, that Schroeder's estimate (*21*) of the annual production of all the land is equivalent to a mean daily production of 0.55 g/m², roughly the same as the value given in Table 1 for short prairie grass.

With regard to the marine data, it is perhaps surprising that net production rates differ by less than a factor of 2 in such diverse environments as a coral reef, a turtle grass flat, a polluted creek, and the Grand Banks. This alone would indicate that production in each case is limited by the same basic factor, the photosynthetic potential of the plants, and indeed these and the other high values in *D* in Table 1 all closely approach the theoretical potential.

Seasonal studies have been made of three marine areas, Long Island Sound, the continental shelf off New York, and the Sargasso Sea off Bermuda. In each case temporary rates of production were observed during the spring flowering which approached the theoretical maximum, but the annual means were more than an order of magnitude lower (*E* in Table 1). True, these regions do not, throughout the year, satisfy the postulated conditions necessary to obtain this maximum, namely, that all light entering the water be absorbed by plants. For example, in his Long Island Sound studies, Riley (*22*) found that no more than one-third of the incident radiation was utilized by plants, the remainder presumably being absorbed by nonliving particulate and dissolved materials. Using Riley's techniques, I estimated that only 25 to 40 percent of the light penetrating the continental shelf waters was absorbed by the phytoplankton. This alone, however, is insufficient to account for the discrepancy between observed and potential production rates. In the clear waters of the Sargasso Sea only 10 to 20 percent of the light is absorbed by the phytoplankton during most of the year. But there is little if any other particulate matter present; the remainder of the light is absorbed by the water itself. This is not a cause but an effect of low production. The underlying reason for low production rates here and in most parts of the ocean is the limitation of essential nutrients in the upper, euphotic layers and the inadequacy of vertical mixing processes in bringing deep, nutrient-rich water to the surface.

With the exception of the three planktonic communities which have been discussed, the seasonal cycles of marine production are largely unknown and can only be surmised. Probably high levels may be maintained throughout the year in benthic populations such as the coral reef, the turtle grass flats (see *D* in Table 1) and in thick beds of seaweeds, provided that seasonal temperature extremes do not impair growth. While the concentrations of nutrients in the surrounding waters may be very low, the fact that they are continually being replenished as the water moves over the plants probably prevents their ever being limiting. Plankton organisms, on the other hand, suspended as they are in their milieu, can probably never maintain high production rates in a given parcel of water, for their growth rapidly exhausts the nutrients from their surrounding environment and any mixing process which enriches the water must, at the same time, dilute the organisms. However, high plankton production may be sustained in a given geographic area (a polluted estuary, a region of permanent upwelling of deep water, and so forth), which is continually replenished with enriched water. In these situations, the productive capacity of the sea may be sustained for long periods, perhaps permanently.

For most of the ocean, as stated above, no such mechanism for nutrient replenishment is available. The combined meteorological and hydrographic conditions which produce the typical spring flowering of the phytoplankton over much of the oceans have been adequately described elsewhere and need not be discussed here. Suffice it to say that, in the oceans as a whole, as seasonal studies have demonstrated, high production approaching the theoretical maximum under optimal conditions is restricted to periods of a few days or, at most, weeks, per year.

Steemann Nielsen (*23*) has recently estimated the net production of the entire hydrosphere as 1.2 to 1.5×10^{10} tons of carbon per year, roughly one-tenth the earlier estimates made by Riley (*24*) and others, and about comparable to Schroeder's figure (*21*) for the land. Our production estimates are somewhat higher than those of Steemann Nielsen, the annual mean net production of organic matter for the Sargasso Sea (0.40 g/m² day) being about 6 times as great as his value for the same area, and twice his average for the oceans as a whole. This discrepancy appears to be largely due to the fact that Steemann Nielsen's values are based on single observations which probably seldom included seasonal maxima. His observations in the Sargasso Sea, for example, were made in June and did not differ greatly from our June values, which were the seasonal minima. If the Sargasso Sea is one of the less fertile parts of the ocean, as is generally believed, then our data would indicate that the seas are more than twice as productive as the land (*25*).

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Robert Redfield, Anthropologist

Although most of his friends and colleagues knew he had been suffering from leukemia for several years, the death of Robert Redfield, on 16 October 1958, brought a sense of shock and loss to them and to scholars and scientists throughout the world. A man who spent most of his leisure reading aloud or listening to music with his family and close friends, Robert Redfield left behind very many who expressed in terms of affection what they felt about the qualities of his mind and spirit. Those who participated with him in seminars and conferences throughout the years of his fatal illness, like those who had known him earlier, were impressed with the incisive brilliance of his mind.

Redfield was trained for the law at the University of Chicago. He practiced briefly but became interested in anthropology in the course of a short trip to Mexico he and Mrs. Redfield made in 1923, and through the influence of F.-C. Cole and R. E. Park. He received a doctorate in anthropology from the university in 1928 and later was named Robert Maynard Hutchins distinguished service professor of anthropology. He served as dean of the division of social sciences, chairman of the department of anthropology, and president of the American Anthropological Association. In 1954 and 1955, respectively, his colleagues in America and Britain awarded him the Viking Fund Medal and the Huxley Memorial Medal in recognition of his scholarship and achievement in anthropology.

His was a genuine inquiring mind; he knew the value of theoretical construction and generalization and the importance of verifying such constructions by marshaling evidence that may be confirmed by others. The dialectical play of Redfield's mind showed itself characteristically in some of the seminars he gave at the University of Chicago. One series of these, on "human nature," alternated with another on the "comparison of cultures." In the former series his main interest was to discover the common human being, while in the latter it was to find the distinctive differences in the ways of mankind. Of the last two papers he wrote, in the summer of 1958, one, for the *Encyclopaedia Britannica,* was on "Man, nature of"; the other, on "Art and icon," intended as a lecture to be given at the Museum of Primitive Art in New York City, brilliantly balances the claims of a relativistic and ethnological approach to primitive art against those of a universal esthetic.

These qualities of the great scientist are evident in Redfield's contributions to anthropology, contained in a series of books written in a clear and adroit style which would in itself have served to distinguish him. The most important of these are: *Tepoztlan, a Mexican Village: A Study of Folk Life* (1930); *Chan Kom, a Maya Village* (written in collaboration with Alfonso Villa Rojas) (1934); *The Folk Culture of Yucatan* (1941); *A Village That Chose Progress* (1950); *The Primitive World and Its Transformations* (1953); *The Little Community* (1955); and *Peasant Society and Culture* (1956).

Perhaps the most distinctive and pioneering of Redfield's scientific contributions is the one he made to our understanding of change in folklike peasant and tribal societies.

In the 1920's, when Redfield first became interested in peasant societies, sociologists, especially those around Chicago, who were inspired by Robert Park, were beginning to study the city, and social anthropologists under the inspiration of Malinowski and Radcliffe-Brown were undertaking functional field studies of relatively isolated tribal groups. Tepoztlan and Chan Kom belonged to neither of these types; they were "intermediate communities" with some of the characteristics of both the primitive tribe and the city. The fact that such intermediate communities resembled the peasant communities of Europe, the Near East, and the Orient, as Redfield noted in *Tepoztlan,* at once gave his studies a direct relevance to the life lived by the great majority of mankind. The particular kinds of change in these communities to which he directed attention—those stimulated by contact with modern Western urban and industrial civilization—continue to be important today. Moreover, his interest in studying these changes as "an example within convenient limits, of the general type of change whereby primitive man becomes civilized man, the rustic becomes the urbanite" immediately linked his observations on contemporary communities to the generic processes of the human career (*1*, pp. 13, 14).

As carried out in the Yucatan studies, the method which Redfield developed for the study of the changing "folk" societies and cultures consisted in an almost simultaneous comparison of four contemporary communities—a tribal village, a peasant village, a town, and a metropolitan city—within a single culture area. These Yucatan studies adapted an approach that was essentially functional and synchronic to the study of social and cultural change. The main interest of the studies was in "the recurrent elements of a describable process" —in those general interrelations of social and cultural characteristics that could be closely correlated with the change from a tribal to a peasant village, from a town to a city.

The conclusion that resulted from the application of this method in Yucatan Redfield reformulated in a more general form to take account of the Guatemalan material and of primitive societies. "In the absence of a money economy," he wrote, "isolated homogeneous societies tend to have well organized cultures and to be sacred and collectivistic," and "increase of contacts, bringing about heterogeneity and disorganization of culture, constitutes one sufficient cause of secularization and individualization" (*2*, pp. 339, 369).

Redfield's concepts of the "folk society" and of a "folk-urban continuum" find their chief significance in relation to this general formulation. They are constructions which enable one to ask questions about the degrees of "folkness" associated with tribal, peasant, and urban societies and cultures. Redfield redefined the concepts of "folk" and "primitive" in terms of degree of isolation, homogeneity, sacredness, and other characteristics.

Redfield did not himself assert the conclusions of the Yucatan studies in universal form. He offered them as hypotheses to guide further research and was quite prepared for the possibility

that the correlation he had found in Yucatan was limited by special circumstances, and "that the association among some of the various characters is more necessarily close than among others, and that besides the long-isolated society with its attendant characters, on the one hand, and the less isolated, heterogeneous society with its characters, on the other, we may recognize subtypes, or types in which various kinds of compromises or combinations of character are found" (*2*, p. 358). Later research by both Redfield and others has qualified the Yucatan conclusions in just this manner, revealing special circumstances and new subtypes (*3*).

In 1948 Redfield revisited Chan Kom, and in the restudy of Chan Kom he tried to understand the changes that had occurred there over 17 years as "the biography of a community, of a people who conceived a common purpose, and of what they did to realize it." It is probably this restudy which impressed upon Redfield the importance of finding a place for aspirations, moods, and reform movements in an anthropological theory of social and cultural change (*4*).

One of the most significant qualifications of Redfield's earlier theory was one he himself added. This was the idea that in studying changes in peasant society and culture one should consider not only the stimulus of modern Western civilization but that of the indigenous non-Western civilizations as well. This led him increasingly to consider the interrelations of different levels of social and cultural organization, manifest in special kinds of networks, centers, and "hinge groups" which mediate between them. The folk-urban polarity gives way to a more inclusive concept of a civilization as an enduring "historic structure" in which little and great traditions, little and great communities, are constantly interacting.

In one respect this later development is a return to the beginning. For even in the Tepoztlan study it was already clear that Redfield was interested in changes going on in Tepoztlan not for their own sake but as examples of generic processes (*1*, pp. 218–223; *5*). The difference is that in his later thinking about

Robert Redfield

civilizations Redfield sees a greater need for the methods and time perspectives of the archeologist and the historian. The earlier side-by-side comparison will continue, "but we shall also develop schemes of comparison that put together in the same class those societies and cultures that have corresponding positions in the same civilizational system or perhaps in different civilizational systems" (*6*). This new kind of comparison will involve the ordering of peoples into tribal, peasant, and urban communities in the context of history.

This view of civilizations as great structures in history, as "systems of cultures in persisting characteristic relationship," was very much on Redfield's mind to the end. During the last 10 years he was actively concerned in his lectures and writing with the problem of how to characterize and compare the great civilizations. In a personal letter dated 13 September 1958, he speaks of his intention "to write a small book on Civilizations. . . . It would consist of perhaps ten essay-like chapters, something like—but in the end probably not much like—the following:

"I. A Civilization as an Object (a formed thing of the mind)
"II. Cultures and Civilizations: Class and Subclass
"III. Criteria (class and continua)
"IV. Structures in History (Societal or Cultural)
"V. Community, Region, Class, Estate
"VI. The Cultivation of Tradition and Self-image: Knowledge
"VII. The Cultivation of Aesthetic Discrimination
"VIII. The Cultivation of Moral Judgment
"IX. The Creativity of the Civilized
"X. The Civilization of the Untraditional."

What might have gone into this book we can only guess from Redfield's last articles and lectures. For most of us it will remain the kind of "ideal" that Robert Redfield's life and work represent, and that he meant when he wrote: "An ideal is a picture of the place you will never quite, but always strive to, reach. Its attainment happens in little pieces of the striving. We shall never have a world of perfectly rational and fair-minded men, just as we shall never have an educational system in which everyone learns to think with the excellences of intellectual conversation that I have imagined. But the great good is contained within the small; the civilization of the dialogue is set forth, however humbly, in any one small piece of honest intellectual exchange, with my neighbor, with my book. A new beginning toward the unattainable is forever right at hand" (*7*).

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News of Science

Test Moratorium Extended; Geneva Negotiations Analyzed in Senate

The President has announced a 2-month extension of the 1-year moratorium on nuclear tests that was scheduled to end on 31 October. The announcement, which was made on 25 August through the State Department, came 5 days after the three nuclear powers—the United States, Britain, and the Soviet Union—had agreed to a 6-week recess of the 10-month-old negotiations for a treaty to end testing. The three-power talks, which have been taking place in Geneva, will resume on 12 October, after the President and Soviet Premier Nikita S. Khrushchev will presumably have had an opportunity to discuss the proposed treaty during their exchange of visits this month.

Treaty Progress

The treaty has 24 articles, and so far agreement has been reached on 17 of them. Broadly, the areas of agreement are as follows. Vienna would be headquarters for a control organization composed of a seven-nation commission, of which the three nuclear powers would be permanent members. An administrator, acceptable to the three powers, would be responsible for operating the control system. There would be 70 to 80 control posts throughout the world, each of which would be staffed by 30 to 40 technicians, plus supporting personnel. The control organization would continuously conduct research to improve the control system. A series of satellites would be launched to assure that tests do not take place in outer space. Other countries may join in the treaty, which would continue indefinitely.

The major areas in which accord has not yet been reached are in the staffing of the control posts, the composition of the control commission, the control system for high-altitude tests, the budget, the equipment at control posts, and the number of on-site inspections.

Humphrey Spokesman for Geneva Talks

Senator Hubert H. Humphrey (D-Minn.), chairman of the Subcommittee on Disarmament of the Senate Foreign Relations Committee, discussed all of these issues in an address to the Senate on 18 August. For months he has been this country's leading spokesman in support of the Geneva conference, consistently pointing out and opposing pressure from the Atomic Energy Commission and the Defense Department for the resumption of nuclear tests. Humphrey has said repeatedly that testing on the part of the United States should not be resumed unless the Geneva test-ban negotiations collapse. In his recent Senate speech he observed: "If tests resume before we know the outcome of the test-ban negotiations the United States will be inviting an outburst of indignation and criticism by the people of other nations."

Humphrey maintains that of all the undecided issues at Geneva, only one really stands in the way of an agreement—that of the number of on-site inspections. He charges that on this major remaining point the United States is in a poor position to negotiate because opinion is divided between two groups—those who are concerned with the risks involved in a continuing arms race and those who feel that there is more to be gained than to be lost by continuing the tests.

Last fall the United States recommended a formula for inspection under which all unidentified seismic events the size of a 5-kiloton explosion or larger, and 20 percent of all events below 5 kilotons, should be subject to inspection. At that time, adoption of this formula would have resulted in about 85 inspections per year. However, after the Hardtack explosions, the figures were revised sharply, so that now the number of inspections would be 366 in the Soviet Union and only slightly less in the United States. Humphrey protested in his recent address that this number, referred to recently by AEC officials, gives the impression that the inspection problem is "so huge that the negotiators might just as well pack up their bags and go home." He then pointed out that at least two-thirds of all earthquakes in the Soviet Union occur in the Kamchatka Peninsula, a very small area, and another 25 percent occur along the southern periphery of the country. The senator believes that a system of representative inspections could be worked out that would greatly simplify the control problem. He pointed out that it would certainly not be necessary to conduct 242 inspections (two-thirds of the number of earthquakes that occur in the U.S.S.R. in a year) in the Kamchatka Peninsula "to satisfy ourselves that the Soviets were not sneaking tests in that area."

Humphrey also suggested that once the earthquake-checking system is installed, more will be known about earthquake patterns, and the identification of nuclear tests will be less complicated.

Executive Branch Criticized

In his comments to the Senate Humphrey was highly critical of the President's role. He said that this country's negotiators are "burdened by obstacles which have been built primarily by the Atomic Energy Commission and to a lesser extent by the Defense Department." He observed: "The AEC is allowed to continue to oppose the official position of the United States and to inject its own views on foreign policy due to a lack of leadership at the top. . . . The President has failed to assert the leadership necessary to reconcile conflicting views." (It was a week later that the President announced the 2-month extension of the moratorium on nuclear tests.)

Humphrey pointed out, further, that one of the recommendations of the Geneva conference of experts last year is being ignored by this country, and that is the possibility of using and re-equipping existing seismograph stations throughout the world. Of the some 650 stations, approximately one-quarter are strategically located. Humphrey proposed that the executive branch recommend that the United Nations establish a special working group to assist other nations in improving and modernizing their seismograph stations.

Another point emphasized in the talk was the government's failure to imple-

ment many of the recommendations of the Panel on Seismic Improvement, of which Lloyd Berkner was chairman. Last year that panel concluded that this country's seismological research should be greatly expanded immediately and proposed a number of important programs, yet the executive branch has not asked for funds to support such work.

Other Aspects Examined

Senator Humphrey put forward still another aspect of the problem in his analysis of the test-ban issues when he urged that the principle of deterrence, the concept underlying other United States defense policies, be applied to the nuclear test control problem. He commented:

"We must accept the fact that we cannot cover every little unidentified event in the Soviet Union to see whether it is an earthquake or a nuclear test. We can, however, demand the right to inspect a certain number of cases on the assumption that such inspections will constitute a spot check system of random sampling which will have a high probability of accuracy and which will deter a nation from thinking a few sneak tests can be held without being caught."

Humphrey emphasized that new scientific data do not preclude the realization of a workable agreement. He pointed out that the scientific problems that have developed during the course of the negotiations in Geneva are not substantially different from those the negotiators faced when the meetings began. He said:

"We knew then that although our techniques of detecting and identifying tests would improve with increased research and knowledge, we would also discover a larger number of natural phenomena with this newer and more sensitive equipment.

"Nothing has changed since last October that justifies our giving up."

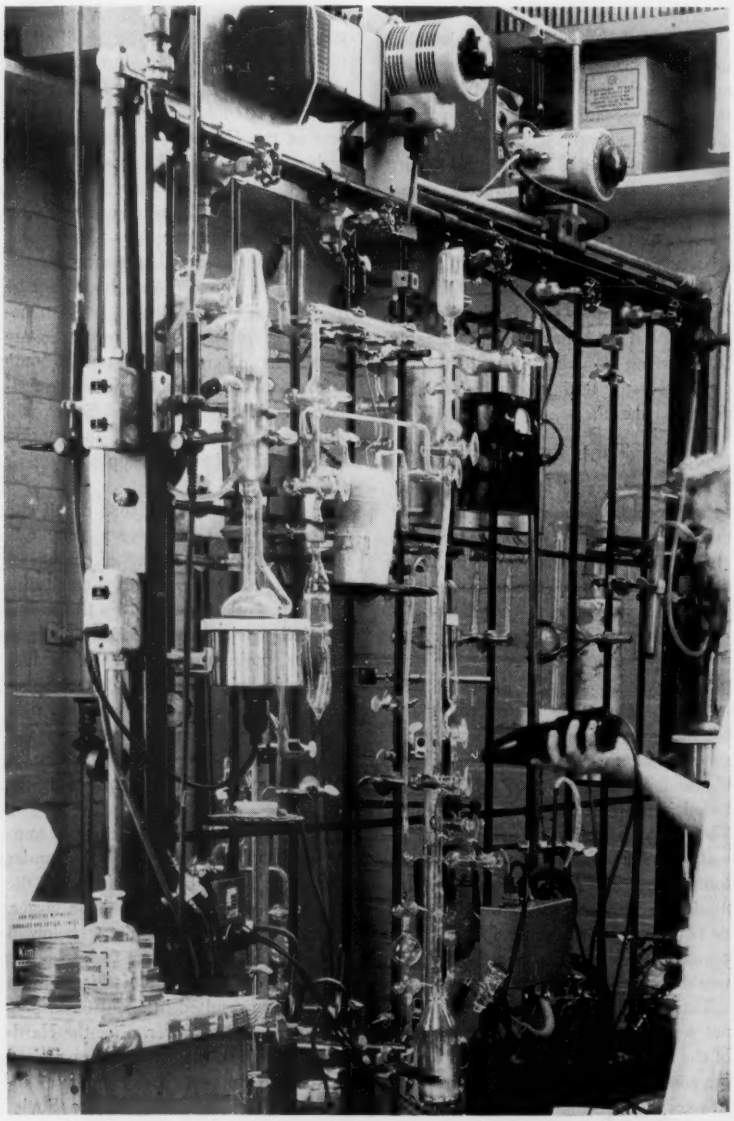
Hydrogen Isotope Studies Applied to Geology

The movement of water in cosmic scale processes and its geochemistry are current projects of the Geochemistry and Petrology Branch of the U.S. Geological Survey. By mass spectrometry, researchers in the nucleonics group are determining the ratios of light to heavy hydrogen in clouds, surface waters, glaciers, rain and snow, and the rocks of the earth's crust in an attempt to learn the earth's past and present water circulation and migration.

Water sometimes takes thousands, even millions, of years to complete the hydrologic cycle from ocean to cloud, to land, to ground water, to surface water, and back to the sea. And in the sea itself there are also known to be large time factors involved in the mixing of the various layers of ocean water and for exchanges with the atmosphere.

Congressional Report Says Current Fallout Not Hazardous but Warns against Test Resumption

On 24 August the Joint Committee on Atomic Energy released a "Summary-Analysis" *of hearings on weapon-test fallout that were held in May before the Special Subcommittee on Radiation. The 42-page report is reassuring about the fallout hazard from past nuclear tests but warns against resuming testing at the level of intensity of the last 5 years. The committee's analysis also points out that*



A U.S. Geological Survey geologist preparing a sample of atmospheric water for hydrogen isotope analysis.

while research efforts have been accelerated in the past 2 years, the fallout program as a whole has not received the high administrative support it needs. It emphasizes that better coordination of fallout information is essential, together with the development and application of adequate radiation standards. The analysis points to the need for better coordination among government agencies in determining, controlling, and evaluating environmental hazards.

A panel of technical advisers that was composed of scientists from both inside and outside the government assisted the subcommittee in preparing for the 3-day hearings. With the help of the panel, a detailed technical outline for the hearings was developed and some 30 expert witnesses were invited to testify. Members of the advisory panel were as follows:

S. D. Cornell, executive officer, National Academy of Sciences.

L. S. Taylor, chief, Atomic and Radiation Physics Division, National Bureau of Standards.

F. J. Weber, chief, Division of Radiological Health, U.S. Public Health Service.

John H. Harley, assistant director, Health and Safety Laboratory, Atomic Energy Commission.

L. Machta, U.S. Weather Bureau.

C. L. Dunham, director, Division of Biology and Medicine, Atomic Energy Commission.

Bentley Glass, Johns Hopkins University.

Hal Hollister, Division of Biology and Medicine, Atomic Energy Commission.

Paul C. Tompkins, Joint Committee on Atomic Energy consultant.

W. Selove, University of Pennsylvania.

William F. Neuman, University of Rochester.

Russell Morgan, Johns Hopkins University (invited but could not attend).

Origin of Fallout

Information developed at the hearings shows that if the test programs of all countries are considered together, the total nuclear yield resulting from these tests has increased markedly since 1954. Of the total 90–92 megatons fission yield equivalent released to date, 40 megatons was produced in 1957–58. The bulk of this was detonated during 1958 in the U.S. Hardtack series and the U.S.S.R. October series. Large portions of the radioactive products produced in this latest series have gone into worldwide fallout due to detonations of large-yield weapons at high altitudes.

As in 1957, testimony at the 1959 hearings indicated that strontium 90 and cesium 137 are still considered to present the greatest hazard in worldwide fallout (fallout away from the testing sites). But shortlived isotopes, such as strontium 89, iodine 131, barium 140, zirconium 95, and others, were described by several witnesses as worthy of more consideration or even potentially equal in hazard to strontium 90 and cesium 137. Similarly, long-lived carbon 14 was described as a potential long-term hazard from nuclear weapons tests.

Distribution of Fallout

The nonuniform distribution of fallout material in the stratosphere and on the ground, which was indicated in the 1957 hearings, has been confirmed. About two-thirds of the stratospheric material has been found in the Northern Hemisphere and about one-third in the Southern Hemisphere.

The estimated mean residence time of material in the stratosphere is now taken as from 1 to 5 years, compared to the 5 to 10 years estimated in 1957. The shortest residence time (about a year) can be expected for debris from the 1958 U.S.S.R. tests in the Arctic.

The rate of deposition of strontium 90 showed an increase in the spring of 1959 in the northern latitudes. Testimony indicated that such an increase may be the result of seasonal fluctuations and/or southward movement of polar air masses, coinciding with the 1958 U.S.S.R. tests in the Arctic. The existence of localized hotspot areas was recognized, resulting among other things from uneven distribution of radioactive debris removed from the troposphere by local rainfall. But the relationship of these hotspot areas to worldwide fallout, if any, remains unclear.

Uptake of Radioactive Isotopes from Fallout

The content of strontium 90 and cesium 137 in food has risen since 1957, even more rapidly than the total fallout. Temporarily high levels have been found in various parts of the country suggesting that under certain conditions strontium 90 may be taken up directly without going through the soil. Therefore, a consistent degree of discrimination (i.e., the selective reduction of strontium 90 in relation to calcium) from the ground to man cannot be expected.

Biological Effects of Radiation

Evidence was presented at the hearings suggesting that the magnitude of genetic effects (i.e., effects on future generations) resulting from a given dose of radiation may, contrary to the general belief in 1957, have a definite relationship to the *rate* at which the dose is delivered. The implication of this evidence is that the effectiveness of a given dose of radiation is less at low dose rates than at high dose rates, even for genetic consequences.

The biological significance of low levels of radioactivity is still largely unknown. No resolution was reached on whether or not a threshold level of radiation exposure exists below which effects such as cancer and leukemia do not result.

Hotspots and Their Significance

The term "hotspot" is used to refer to local areas, geographically speaking, where environmental contamination levels are considered to be higher than average levels in other areas of the country with which comparisons are being made. That such hotspot areas exist was not disputed; yet one of the ambiguities in the hearings testimony was the fact that no completely satisfactory definition was presented of what a hotspot is, how the limits of such an area are defined, and what the problems involved really are.

Some testimony suggested that higher radiation levels in limited areas do not, any more than other nonuniformities, increase the overall hazard of fallout to the world's population. This contention is based on the argument that the total hazard is related to the total dose of radiation received by an entire population, and is not related to geographic distribution. It is evident, however, that more data and greater consideration of how to evaluate the data are needed before a satisfactory answer to this problem can be worked out.

Significance of Short-lived Isotopes

According to the testimony, recent fallout samples have concentrations of short-lived isotopes which are equal to and in many cases higher than those of the longer-lived isotopes such as strontium 90 and cesium 137. Due to their relatively rapid decay, the total radiation dose they deliver is ordinarily only a small fraction of that delivered

by the longer lived isotopes. However, the short-lived isotopes may be acquiring more significance than previously thought in view of the fact that fallout from the stratosphere has proven to be faster than estimated earlier, together with the possibility of selective concentration in some particular organ of the body (i.e., radioactive iodine in the thyroid). The question apparently merits greater attention than it has received in the past, particularly in forecasting the effects of future tests.

Significance of Carbon 14

Information provided for the hearings suggests that radioactive carbon 14 from past weapons tests could constitute a genetic hazard to the world's population. The magnitude of this hazard has been estimated to be comparable to, and in some estimates in excess of, the genetic hazard from other fallout isotopes. One of the principal problems in making these estimates is how to assess the hazard of a dose which may be comparable in magnitude to that from cesium 137 and other genetically hazardous fallout isotopes but which occurs over a much longer time period (the equivalent of 8,000 years compared with 40 years or so). Here again, a problem was presented for which available information appears to be inadequate. Greater emphasis should be given to means by which this problem may be properly evaluated.

Maximum Permissible Dose and Maximum Permissible Concentration

It was generally agreed that in considering acceptable exposure limits in the context of worldwide environmental contamination from fallout, the best assumption that can be made at present concerning the relationship of biological effect to radiation dose is to assume that any dose, however small, produces some biological effect and that this effect is harmful. The testimony made it clear that much difficulty now exists in evaluating the hazards of environmental contamination from worldwide fallout. This is because of the difficulty in attempting to apply to whole populations exposed to fallout the concepts behind "maximum permissible dose" and "maximum permissible concentration," which were developed for occupational exposures to individuals under controlled conditions.

Even if concepts developed for industrial application were clearly transferable, the testimony suggested confusion over such points as to how to apply existing maximum permissible concentrations for water to food in the fallout situation, how to handle diets (what time period to consider when "averaging"), and how to allow for the possible presence of other isotopes than the one being considered.

Further evidence of confusion concerning hazards evaluation in the testimony presented was given by the use, on the one hand, of industrially oriented exposure recommendations discussed above and by the use, on the other hand, of comparisons with natural background radiation levels. At present, it appears that each controversial situation involving fallout exposure is evaluated on an ad hoc basis, but with little understanding or agreement on how the evaluation is to be done.

Effects of Past and Future Tests

It was forecast that the average concentration of strontium 90 in human bone from past weapons tests will reach its maximum value in the period 1962–65. The predicted U.S. average value of 6 strontium units (S.U.) is slightly higher than for average Western populations (5 S.U.) and lower than the average for Eastern peoples (10 S.U.). Thus for testing already conducted, man's exposure to fallout radiation is and will be relatively small compared to the "normal background" radiation or the standard recommended by the International Commission on Radiological Protection (ICRP).

Assuming successive cycles of testing over the next two generations or less, following the same pattern as the past 5 years, the predicted average concentration in bone will be about 48 strontium units. This is close enough to the maximum permissible body burden of 67 strontium units recommended by the International Commission on Radiological Protection to suggest that a hazard to the world's population could result during this period.

Alternative Patterns of Testing

Testimony at the hearings indicated that—

Underground tests can be conducted with relatively small weapons, without contaminating the atmosphere with radioactivity. Great practical difficulties exist for testing large or megaton weapons underground.

Outer space tests can be conducted under conditions—among which are distance and yield of the device—which will reduce atmospheric contamination to an as yet unknown degree. To obtain test data, there exist practical problems of instrumentation which would require further tests in space to resolve.

Environmental testing is necessary to establish effects of nuclear weapons on military targets, equipment, radiation levels, etc.

Government Program and Organization

While the AEC has accelerated its efforts in fallout research in the past 2 years, particularly in sampling and analysis, the fallout program as a whole apparently has not received the high administrative level support it needs to give it the necessary impetus. Increased dollar outlays for facility and operating expenses have been useful but further improvements in the program, its administration and its organization, are required. These should include adequate staffing in the AEC Biology and Medicine Division to meet the broad requirements of an expanding program. Better coordination by the AEC of fallout information is essential. Adequate radiation standards must be developed in cooperation with the various Federal, State, and private agencies.

The Public Health Service, which has been conducting a survey of radioactive fallout debris in milk, operates a research laboratory in Cincinnati and has a newly created staff in Washington. However, expenditures and numbers of personnel remain small.

With regard to the fallout program, increased emphasis should be placed on the "hot spot" program, declassification and periodic publication of useful information, development and application of exposure standards, and better coordination among Government agencies in determining, controlling, and evaluating environmental hazards.

In implementing an effective program, the first job is to define clearly what the real problems are and then assign responsibilities for meeting these problems. In the process, care should be taken not to interfere with existing programs which are making major contributions to knowledge in the fallout field.

Scientists in the News

CHARLES A. ANDERSON has been named chief geologist for the U.S. Geological Survey, a position recently vacated by WILMOT H. BRADLEY, who was appointed in 1944. Anderson, whose career with the Survey began in 1942, has been heading the Mineral Deposits Branch.

ARTHUR W. GRACE, professor and head of the department of dermatology and syphilology at the State University of New York Downstate Medical Center for more than 20 years, has retired and has been named professor emeritus of dermatology and syphilology. A native of Australia, he completed his studies in medicine and public health at the University of London, England, and also received the Diploma of Tropical Medicine and Hygiene of the Conjoint Board of Physicians and Surgeons of England in 1924.

He came to this country in 1931 as a member of the faculty of Cornell University Medical College, where he remained until he joined the Downstate Medical Center. Grace will continue his medical practice in Brooklyn and his duties as director of a research project on blood vessels of the skin at the Medical Center. At present he is in Africa for 2 months, delivering a series of lectures on skin and venereal diseases.

HENRY C. HARRISON, retired electrical engineer of Bell Telephone Laboratories, will be awarded an Elliott Cresson Medal by the Franklin Institute, Philadelphia, Pa., on 21 October.

FRANKLIN W. STAHL, associate professor of zoology at the University of Missouri, has been appointed associate professor of biology in the Institute of Molecular Biology of the University of Oregon.

VALY MENKIN, associate professor of experimental pathology at Temple University School of Medicine, has resigned and will be a guest investigator at the Henry Phipps Institute of the University of Pennsylvania, Philadelphia.

WAYNE TAYLOR has been appointed associate professor in the Science and Mathematics Teaching Center at Michigan State University. He was formerly on the staff of the University of Texas, where he served as center coordinator for the AAAS Science Teaching Improvement Program's Center for the Study on the Use of Science Counselors. Taylor is vice chairman of the AAAS Science Cooperative Committee on the Teaching of Science and Mathematics.

President Eisenhower has named ARTHUR S. FLEMMING, Secretary of Health, Education, and Welfare, chairman of the new Federal Radiation Council [see *Science* **130**, 490 (1959)].

Charles A. Anderson, chief geologist, U.S. Geological Survey.

HORACE M. POWELL, research adviser in the biological research division of Eli Lilly and Company, has retired after having been affiliated with the Lilly Research Laboratories for 34 years.

ALEXANDER H. FLAX, vice president and technical director of the Cornell Aeronautical Laboratory, has been named chief scientist of the Air Force. He will serve as scientific adviser to the Air Force Chief of Staff.

HOWARD W. JOHNSON, associate dean of the School of Industrial Management at Massachusetts Institute of Technology, has been appointed dean of the school effective 1 November. He will succeed E. P. BROOKS.

JOHN W. ROSS, formerly research microbiologist and biochemist at the Red Star Yeast and Products Company, has been appointed senior research microbiologist at the Squibb Institute for Medical Research, New York, N.Y.

DAVID F. BROWER, atomic physicist at General Dynamics Corporation, San Diego, Calif., has been appointed assistant manager of the engineering department of Rheem Semiconductor Corporation, Mountain View, Calif.

EDWARD W. D. NORTON, associate professor of ophthalmology at the University of Miami School of Medicine, has been appointed professor and chairman of the university's department of ophthalmology. The newly formed department was formerly a division of the department of surgery.

SIDNEY RIEGELMAN, assistant professor of pharmacy at the College of Pharmacy of the University of California Medical Center, San Francisco, was awarded the Ebert Prize at a recent meeting of the American Pharmaceutical Association for his paper "The kinetics of rectal absorption of anions and of undissociated molecules."

I. THOMAS REAMER, chief pharmacist at Duke University Hospital, has received the 1959 Harvey A. K. Whitney Lecture Award of the American Society of Hospital Pharmacists.

PAUL D. ROSAHN, pathologist at the New Britain General Hospital, New Britain, Conn., and associate clinical professor of pathology at Yale University School of Medicine, has been appointed visiting professor of pathology at the University of Medical Sciences, Bangkok, Thailand, for 1 year, beginning in September.

Recent Deaths

ANTHONY BASSLER, New York; 85; specialist in gastroenterology, who had practiced medicine for more than 60 years; former professor of gastroenterology at the Polyclinic Medical School and Fordham University; founder and chairman of the section on gastroenterology of the American Medical Association; 20 Aug.

FLANDERS DUNBAR, South Kent, Conn.; 57; psychiatrist with a private practice in New York; pioneer in psychosomatic medicine; author of *Psychiatry in the Medical Specialties*; 21 Aug.

LEE F. HAWLEY, Madison, Wis.; 77; retired research chemist and one of the founders of the U.S. Forest Products Laboratory; 19 Aug.

F. S. McKAY, Colorado Springs, Colo.; 85; dentist and a pioneer in the fluoridation of drinking water; 21 Aug.

A. FRANK OWINGS, Washington, D.C.; 37; deputy assistant director for Technical Information Service, U.S. Atomic Energy Commission; 15 June.

WILLIAM STROUD, Philadelphia, Pa.; 68; chairman of the department of cardiology at the University of Pennsylvania Graduate School of Medicine and chief of staff at Children's Heart Hospital; 19 Aug.

***Errata*: In Wilder Penfield's article, "The interpretive cortex," [*Science* 129, 1719 (26 June 1959)], the word *psychical* should be substituted for *physical* on page 1719, column 3, line 15. On page 1723, column 3, last line, reference should be made to Fig. 6, not Fig. 3.**

Book Reviews

Science Study Series. *The Neutron Story.* Donald J. Hughes. 158 pp. *Echoes of Bats and Men.* Donald R. Griffin. 156 pp. *Magnets.* The education of a physicist. Francis Bitter. 155 pp. *How Old Is the Earth?* Patrick M. Hurley. 160 pp. *Soap Bubbles.* And the forces which mould them. C. V. Boys. 156 pp. Doubleday, Garden City, N.Y., 1959 (available to secondary-school students and teachers through Wesleyan University Press, Columbus 16, Ohio). Illus. Paper, $0.95 each; $1.10 in Canada.

These five volumes bring new life and vigor to a field largely dominated by formal textbooks. First in a series of paperback editions, they form a stimulating link between scientists and laymen. Largely dissimilar in subject matter, all the books bear the earmark of the authors' enthusiasm and scholarly competence. The first four books break down the time gap that too often separates textbooks from the latest developments in science. The fifth book, *Soap Bubbles,* is in a class by itself, since it was first published in 1902 by the Society for Promoting Christian Knowledge, of London.

Criticism of the encyclopedic nature of traditional secondary-school physics courses motivated a committee of physicists, high-school teachers, and other specialists meeting at Massachusetts Institute of Technology in 1956 to devise a fresh approach to the teaching and study of high-school physics. A guiding principle of the Physical Science Study Committee, established to develop the new course, is the emphasis on fundamentals rather than on detailed application. The purpose of the "Science Study Series" is to bring specialized fields of physics not only to physics students but to the general public as well. Although the amount of mathematics included is reduced to a minimum, there is real substance in all the books.

In his preface to *The Neutron Story,* Donald Hughes writes: "The Neutron Story, I feel, is scientific fact whose meaning and beauty can be transmitted without higher mathematics or headlines. It is my conviction that in this you will agree—the story has elements of mystery, profundity, and beauty, whose significance can be conveyed to those without technical training who are willing to put their minds to it."

In chapter 1 the versatility of the neutron in nuclear research is related to its penetrating property, which results from the absence of electrical interaction with its subatomic particles. Hughes gives a brief history of our knowledge of the neutron, discussing its discovery in 1932, its role in the fission of uranium (1939), its application in chain reactions and in the production of radioisotopes, and its promise in revealing the innermost structure of matter.

In chapter 2 there is a lucid review of our knowledge of the structure of the atom, beginning with Rutherford's demonstration of the compact nature of the nucleus. The puzzle of nuclear structural differences in isotopes, once explained in terms of pairs of protons and electrons inside the nucleus, is made clear by a nonmathematical reference to wave mechanics. Chadwick's discovery of the neutron is described, as well as evidence leading to the conclusion that "the neutron is actually a fundamental particle, existing in its own right, and constituting a basic component of matter."

In chapter 3 the duality of the neutron is explored, and the wave nature of the particle is related to the speed of the neutron. Again a nonmathematical treatment of quantum mechanics is ably used. Crucial experiments in neutron refraction and reflection are discussed.

Chapter 4 considers the inner structure of the neutron and how it can be altered profoundly. Neutron disintegration, the neutrino, the explanation of the magnetic field of the neutron in terms of the meson, and polarized neutrons are presented.

Striking examples of the nuclear effects of neutrons make up chapter 5. Neutron capture by a stable nucleus may lead to radioactive forms. The function of the moderator in improving neutron capture is related to the wavelength of the neutron. The Gamow neutron-capture theory of the origin of the elements is an intriguing bridge between the infinitesimal and the infinite.

Chapter 6 is a fascinating discussion of neutron experiments in solid-state physics. The use of fast neutron bombardment to produce changes in crystal structure is shown to have wide practical importance.

Chapter 7 discusses "cold" neutrons and how they are used to reveal atomic motions. Chapter 8 concludes the book, with an explanation of the chain reaction in the fission and fusion bomb, in reactors, and in the thermonuclear reactor.

"We have had another revelation of how infinitely intricate are the relationships of subatomic particles, how wondrous the scheme of the universe as revealed in the world of the very small," concludes Hughes.

Echoes of Bats and Men, by Donald Griffin, professor of zoology at Harvard, well illustrates the far-ranging values of physics—for example, in solving problems in biology. "A century-old mystery of zoology was largely dispelled by one afternoon in the appropriate physics laboratory," states Griffin.

The theme of the book is accurately expressed in the preface: "Man has been said to 'stand between the atoms and the stars' and between molecules and men are to be found many fascinating applications of physics, broadly conceived. Outstanding among these are ways in which living organisms utilize wave motion of various kinds. Of particular interest is the interplay between sound waves and the animals and men who use them."

Recently perfected sonar and radar techniques for ranging are "old hat" to porpoises and bats. Griffin's descriptions of ingenious experiments devised to uncover the secret of the navigational skill of porpoises and of bats in darkness makes fascinating reading. "To have survived at all required of these animals and their ancestors enormous skills at echolocation, the location of objects by their echoes."

Enough is presented of the principles of sound to make the book understandable to readers who have no background in physics. A number of simple experiments are described in which a toy "clicker" or a tape recorder is used to explore sound ranging at first hand.

Explanations of radar and sonar are given. For the quantitative-minded, an

entertaining comparison is made between the echolocation efficiency of an airborne radar system and that of a large and of a small bat.

The book concludes with a review of experiments that explain how blind people are able to find their way around, largely by echolocation. A final question for further research is posed: Why do blind men fail to learn as much from echoes as they theoretically should?

Each of the five books reviewed here has a different emphasis. *Magnets* is essentially the personal story of the education and professional career of Francis Bitter, professor of physics at Massachusetts Institute of Technology. His book will appeal to students and laymen because it presents some of the latest ideas about the origin of magnetism in a largely nonmathematical way. The personal nature of the book, which conveys the author's continuing enthusiasm for research, poses a number of still-unanswered questions in magnetic theory, and shows Bitter's honesty in searching for the truth, may well be an inspiration to student readers.

The viewpoint of the book is revealed by Bitter in the preface: "I shall tell you about magnetism in the most valid way I know—and in an interesting way, I hope—by describing my personal voyage of exploration, and how it felt to me. . . . But you will learn *something* about magnetism, and perhaps quite a lot of a man's life and his absorption in his work."

After a brief description of his childhood, the author reviews several basic principles of magnetism: the inverse square law, magnetic fields, and electromagnetism. Bitter's deep involvement in magnetism began with his doctoral thesis on the magnetic susceptibility of hydrocarbons. It was the era of the application of quantum mechanics to magnetism, and the author conveys the enthusiasm with which experimental verification of quantum predictions was sought.

Bitter then studied ferromagnetism, in the research laboratories of Westinghouse, applying theory to improve the magnetic qualities of iron. Subsequently, at Massachusetts Institute of Technology, he designed electromagnets of very great strength to explore the electronic structure of complex atoms. His work during world War II in degaussing ships led to further application of magnetic principles. Magnetic resonance, one of the most important techniques in studying nuclear structure, is well explained.

Bitter's conclusion of this story about himself and about magnetism is in character. "And finally, have you a feeling that the pursuit of science is a most exciting treasure hunt, and that clearly expressed and reliable knowledge is one of our greatest treasures?"

Through application of our knowledge of radioactivity, vast strides have been taken in all the sciences. In *How Old Is the Earth?,* advances in geophysics are presented for students and for the public. The theme of the book is stated in the preface: "Not only has radioactivity supplied most of the energy for the earth's great geologic events; it also measures the time at which these events have occurred. As we shall see in later chapters, each grain of sand, each minute crystal in the rocks about us is a tiny clock, ticking off the years since it was formed. It is not always easy to read them, and we need complex instruments to do it, but they are true clocks or chronometers. The story they tell numbers the pages of earth history."

This book requires careful reading, for each page offers food for thought. But to read it can be rewarding, for it can lead to an insight into geologic principles. The book opens with a review of the structure of the earth. Seismological methods and the isostasy process are clearly explained. The large amount of energy that is expended in the formation of mountains and in other changes in the interior of the earth requires an almost endless source of energy. Evidence is presented to show that the major source of this energy is the activity of radioactive components of the earth, which are largely concentrated in the near-surface layers. A long chapter is devoted to explaining fundamental principles of radioactivity.

A discussion of the measurement of geologic time by sedimentary strata is followed by a thorough exposition of calculations based on radioactive measurements. Conditions necessary for isotopic studies in crystals are given, together with sample calculations. Carbon-14 dating, its applications and its limitations are described. The book ends with speculations on the origin of the solar system and the elements.

It may seem strange indeed that *Soap Bubbles,* first printed in 1902, should be included in the modern "Science Study Series." And yet the book should be of great interest to students, teachers, and laymen. It is a masterpiece of exposition, discussing the widespread effects of surface tension in molding soap bubbles and explaining some strange natural occurrences.

In the latter part of the 19th century, when the classical foundation of science was being established, there was intense popular interest in the rapidly growing physical sciences. Public science lectures that featured remarkable demonstrations attracted enthusiastic throngs. John Tyndall, the English master of physics demonstrations, said in his preface to *Heat: A Mode of Motion*: "In the following lectures I have endeavored to bring the rudiments of a new philosophy within the reach of a person of ordinary intelligence and culture." Following in Tyndall's footsteps, C. V. Boys presented three lectures before a juvenile audience at the London Institution in 1889. This book is the record of those demonstrations. The style of the book is well illustrated by the opening paragraph: "I do not suppose that there is any one in this room who has not occasionally blown a common soap bubble, and while admiring the perfection of its form, and the marvellous brilliancy of its colours, wondered how it is that such a magnificent object can be so easily produced.'

In the first lecture, experiments are presented which establish the remarkable elastic properties of the "skin of water" (surface tension). "You see that it is quite possible to go to sea in a sieve —that is if the sieve is large enough and the water is not too rough. . . ." Capillarity, the cleaning action of benzene on grease, and the role of ox-gall in promoting the spreading of artists' colors are explained by some of the experiments described.

Lectures 2 and 3 should be studied by science teachers as models of the masterly use of visual aids in demonstration. Microprojection, photographic slides, stroboscopic projection, and action-stopping pulse photography are used to produce startling and inspiring demonstrations. In view of the simple materials needed to perform the experiments and the clarity of the "practical hints" (about 30 pages), this book should be a source of inspiration to students in presenting demonstrations and special reports.

I shall use these and subsequent volumes of the "Science Study Series" in my physics classes at the Bronx High School of Science. Perhaps the comments of one student who read *The Neutron Story* will interest other students: "Excellent . . . in a class by itself . . . first book suitable for high school students with enough details, yet requiring only simple math."

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Chromatographic Reviews. Progress in chromatography, electrophoresis, and related methods. vol. 1. Michael Lederer, Ed. Elsevier, Amsterdam, Netherlands, 1959 (order from Van Nostrand, Princeton, N.J.). ix + 276 pp. Illus. $8.75.

Those who recall, for example, the search for specific precipitants for each of the 20-odd amino acids in protein hydrolyzates, or the innumerable fractional crystallizations required for the separation of the rare earths, appreciate the revolution in biological and inorganic chemistry that chromatography has brought about. This is a book that reports progress in that revolution, a book that could equally well be described as a monograph, a bound volume of a journal, or a supplement to the widely used *Chromatography* by Lederer and Lederer. Of the nine chapters, four have been translated from the French or German in which they appeared in the *Journal of Chromatography*. Reio's chapter on new equipment for recording chromatograms and its application to phenol derivatives represents original work. The longest chapter is a translation of Neher's monograph on the chromatography of sterols and related compounds. Other chapters deal with the chromatography of the curare alkaloids, chloroplast and anthocyanin pigments, and inorganic phosphorous compounds. Demole describes the preparation of films on glass for use in adsorption chromatography, and two chapters are devoted to electrophoresis.

Much of the work refers to paper chromatography, but results with columns and with disperse, solid phases other than cellulose are reviewed in some instances. In their discussion of solvent systems all of the contributors utilize the concept of polarity, but the discussion is presented in such general terms that the selection of the most suitable system for a given mixture remains largely empirical. Less frequently an attempt is made to relate the structure of the material being chromatographed to its R_f or R_s value. Although chromatography is useful in structure determinations, all authors agree that this technique must be supplemented by one or more of the classical procedures of organic chemistry.

The review of high-voltage electrophoresis by its originator, Michl, will doubtless help to overcome the lag in the use of this method. One marvels at the separation of the amino acids that are obtained when the mixing effect of diffusion is minimized by the use of steep potential gradients. Included in this chapter are data on other materials of biological interest. From the results reported by Chemla, it appears that the failure of Kendall to separate the lithium isotopes by electrophoresis was due to the insensitivity of the method of isotopic analysis that he used in this pioneer work. The mobility differences of many of the isotopic ions are now known, however, and it is of interest to note that these differences are less for the hydrated ions in aqueous media than for the same ions in fused salts.

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Trigonometric Series. vols. 1 and 2. A. Zygmund. Cambridge University Press, New York, ed. 2, 1959. xii + 383 pp.; vii + 354 pp. $15 per volume; $27.50 per set.

The first edition of this treatise appeared in the collection *Monografie Matematyczne* in Warsaw in 1935. The young, brilliant author was professor at the Polish university of Wilno. The book was accepted right away as the standard text in the field. It was reprinted in New York after the war, when the Polish edition became unavailable. (Zygmund has been in this country since 1940, at the University of Chicago since 1947). In a way it is fitting that the new edition should be published by the Cambridge University Press, for much of the theory stems from Cambridge, and much of the preparation of the manuscript of both editions was done while the author was a visitor there. It is only a pity that publication of such a magnum opus cannot be supported by a subvention that would bring the price within the budget of the average American mathematician.

In the revision, the single volume has become two. The first volume contains most of the material of the original edition, greatly expanded and brought up to date. A considerable part of the second volume is completely new. The treatise is likely to maintain its role as the standard text in the field for another couple of decades. It is essentially classical mathematics at its best. It deals with trigonometric series and the many contacts which this theory has with real and complex variables. It is not concerned with modern harmonic analysis, and there is no mention of group characters. The author, in his preface, calls attention to the fact that the theory of trigonometric series has been a source of new ideas for analysts during the last two centuries, and he adds that it is likely to be so in years to come. I heartily agree.

A list of the contents will give the reader of this review a notion of the wealth of material included in the treatise. There are nine chapters in volume 1: (i) Trigonometric series and Fourier series. Auxiliary results; (ii) Fourier coefficients. Elementary theorems on the convergence of $S[f]$ and $\tilde{S}[f]$; (iii) Summability of Fourier series; (iv) Classes of functions and Fourier series; (v) Special trigonometric series; (vi) The absolute convergence of trigonometric series; (vii) Complex methods in Fourier series; (viii) Divergence of Fourier series; (ix) Riemann's theory of trigonometric series. There are eight chapters in volume 2: (i) Trigonometric interpolation; (ii) Differentiation of series. Generalized derivatives; (iii) Interpolation of linear operations. More about Fourier coefficients; (iv) Convergence and summability almost everywhere; (v) More about complex methods; (vi) Applications of the Littlewood-Paley function to Fourier series; (vii) Fourier integrals; (viii) A topic in multiple Fourier series. Historical notes and an excellent bibliography complete the volume.

The printing and format are first rate.

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Population: An International Dilemma. A summary of the proceedings of the conference committee on population problems, 1956–1957. Frederick Osborn. Population Council, New York, 1958. ix + 97 pp.

This modest volume summarizes discussions held over a period of 2 years by a committee set up by the trustees of the Population Council. The purpose of these discussions was to explore the nature of the population crisis and to attempt to define steps which might be taken to resolve it. Discussants ranged from statisticians to clergymen, from the director of an institution concerned with international education to the author of a book on the depletion of resources.

Frederick Osborn, director of the

Population Council, has condensed the 500 typed pages of memoranda and transcript into 89 printed pages.

The book is divided into two parts: "Outline of present conditions"; and "Indicated lines of action." This thought-provoking survey should be required reading for every person concerned with the population problem, which the United Nations has described as having an "importance which transcends economic and social considerations. It is at the very heart of the problem of our existence."

In his summary, Osborn reviews some of the difficulties involved in getting to the heart of this dilemma: "The attempt to control mortality is becoming a major social activity all over the world. The resulting decline in deaths is bringing about rapid changes in population trends. The rate of population growth in many underdeveloped areas is now much greater than was ever experienced in European countries. In most of the others it will be so in the foreseeable future. And the population base is far larger than it ever was in Europe. Unless an effort equal to that made for the control of death is made for the control of fertility, and unless a reduction of births is achieved within a few decades, the hopes of great but underdeveloped nations for better conditions of life may prove futile, while the present standard of economically advanced nations will decline. Such a tragic failure to achieve the higher levels of living that should be possible could only bring disillusion, confusion, and the danger of resort to desperate measures."

The concern with this "central problem," voiced by the United Nations, appears to be amply justified.

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The Great Pulse. Japanese midwifery and obstetrics through the ages. Mary W. Standlee. Tuttle, Rutland, Vt., 1959. 192 pp. Illus. $4.50.

Japan's medicine, even more than her culture, is a product of successive foreign influences which were superimposed upon the indigenous practices, adapted locally, and blended into a colorful mosaic. The art of writing was unknown in Japan before the introduction of the Chinese character in the 6th century A.D., and all knowledge of earlier ideas had to be culled from uncertain sources and from surviving practices of the basic Shinto religion. Documentation began with the earliest medical books taken bodily from the Chinese.

Japanese obstetrical practice, however, obviously antedated the advent of the written word. As in all early cultures, Japanese women were attended in pregnancy and childbirth by untrained female relatives and neighbors or by midwives with varying degrees of skill. The tenets of Shinto make it evident that all natural female functions, such as menstruation and childbirth, were considered ritual impurities which demanded segregation of the individual. The first Chinese book used in Japan pronounced pregnancy a disease of the blood and so strengthened the taboo aspect of this condition.

According to this oldest known Chinese medical classic, the *Huang Ti Nei Ching Su Wen,* diagnosis of early pregnancy was made from the pulse. "The great pulse," the name by which this symptom was known, was taken as the title for Mary Standlee's book. In this work she describes the amalgamation of indigenous practices and beliefs with those of foreign origin. Throughout the narrative two essential points recur again and again: the wealth of persistent superstition of ancient origin that surrounds pregnancy and childbirth and the continuing employment of midwives as the chief obstetrical attendants in present-day Japan.

The book is the only Western study which deals with the complete history of Japanese obstetrics, and, as such, it is a welcome and important contribution. Unfortunately, the author admittedly is not thoroughly familiar with Oriental thought, and this deficiency is noticeable, although she acknowledges the help of experts. This lack is manifest in her treatment of the ancient basic Chinese concept of the Yin and the Yang, the universal dual force whose balance assures peace and health and whose imbalance brings disaster and disease. The author's approach to this abstract concept is oddly feministic, revealing her resentment that negative attributes are symbolized by Yin, the female half of the dual force. Although her reaction is disguised by awkward jocular expressions, it appears to indicate that she equates this cosmic force with the subordinate position of women in Japanese society. Similarly, the résumé of the legends of the Divine Age, dealing with the origin of the imperial family, is given in a bantering manner which may be intended to lighten the tedium of dynastic history but falls short of being amusing.

Passing references to Japanese medicine also reveal a lack of knowledge of some of its fundamental elements. Although acupuncture and moxa treatment are frequently mentioned as "panaceas," the theory underlying their use is never explained. And the *Huang Ti Nei Ching Su Wen,* the oldest Chinese book on internal medicine, is referred to as "the materia medica of early Chinese civilization," although its emphasis on medicinal substances is negligible compared to that of the *Pen Ts'ao,* which is devoted exclusively to drugs.

These flaws will be disturbing mainly to those familiar with the history of the Far East, who will find the book lacking in depth. To the less critical reader, for whom it is apparently intended, it will prove interesting and informative. The material dealing with more recent events is drawn from essentially good personal observation, and is accurately presented. The illustrations are well selected and excellently reproduced.

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Mutilaciones Dentarias Prehispanicas de México y America en General. Javier Romero. Instituto Nacional de Antropología e Historia, Mexico City, 1958. 326 pp. Illus.

The practice of filing the edges of the front teeth into various shapes or of ornamenting the labial surfaces of the upper front teeth with inlays of jadite, pyrite, turquoise or (rarely) gold, never had very wide acceptance among prehistoric American Indians. In the main, it was restricted to the high-culture populations of what is now Mexico, Guatemala, and British Honduras—in other words, Meso-America. From this center, elements of the practice are believed to have spread northward, up the Mississippi Valley to the region of the present city of St. Louis, and southward to what is now Ecuador, without, however, leaving traces in the intervening regions. Traces of this custom have been found, also, in the American Southwest and as far away as Bolivia, Chile, and Argentina. Surprisingly, nothing of the sort has been found in Panama and Peru.

Such is the picture that Javier Romero, director of the Department of Physical Anthropology at the Instituto Nacional de Antropología e Historia in Mexico City, presents in this attractive and well-planned publication. For evidence, he includes a catalog of 618 teeth, of which some have not previously been described. Also, he discusses in detail such things as the classification of mutilation types and patterns; the age and geographical distribution of the specimens; the relationship of the practice to age, sex, and cranial deformity; and the significance of the practice in the social hierarchy. As the title indicates, he has not confused the picture by including discussion of a similar practice introduced in historic times by African slaves.

The summary, which is given also in English, includes the following points: 51 forms of tooth mutilation are now known; predominance of the practice in one sex or the other varies from period to period; all of the specimens were judged to be from individuals 18 years of age or older; no exclusive association between the practice and the social hierarchy has been established; the practice has been traced back to the pre-Classic period of Mexico, or to about 2800 years before the discovery of America.

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Faune de France. 62. *Coléoptères Curculionides,* vol. 3. Adolphe Hoffmann. Lechevalier, Paris, 1958. 545 pp. Illus. F. 642.

This is the third and final volume by Hoffmann on the Curculionidae of France. It deals with the following subfamilies, as listed in the Junk *Coleopterum Catalogus*: Tychiinae Cioninae, Nanophyinae, Gymnaetrinae, Rhynchaeninae, Cryptorhynchinae, Trachodinae, Erirhininae, Apioninae, Apoderinae, Attelabinae, and Rhynchitinae.

In this volume, as in the two preceding ones, Hoffmann does not, in many instances, follow the modern plan of arrangement of higher categories of Curculionidae. He lumps the 12 groups listed above into three subfamilies—namely, Calandrinae, Apioninae, and Rhynchitinae. To list all the nomenclatorial changes would be impractical, but a few should be called to the users' attention, such as the use of the generic name *Grypidius* Stephens for *Grypus* Germar (footnote, page 1425); the use of the generic name *Eteophilus* Bedel for *Dorytomus* Germar (footnote, page 1437); and the use of the generic name *Cryptorhynchus* Illiger for *Sternochetus* Pierce. The author has either disregarded or does not know the procedures in taxonomy regarding the validity of generic names for he has ignored article 25 of the Rules of Zoological Nomenclature in this otherwise well-presented work.

Keys to the tribes, genera, and species that are treated are given. This, being the final volume, contains a supplement of additions and corrections and an alphabetical index to the three volumes which includes subfamilies, tribes, subtribes, genera, subgenera, species, subspecies, varieties, and synonymies. A 38-page index to the host plants and a list of botanical families appear in this volume.

The author has undoubtedly spent much time and effort on this work, and it will indeed be of help in identifying the weevils of France.

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New Books

Aids to Bacteriology for Nurses. E. Joan Bocock and Katharine F. Armstrong. Bailliere, Tindall and Cox, London, 1959 (order from Williams & Wilkins, Baltimore, Md.). 186 pp. $3.

Alcoholism. The nutritional approach. Roger J. Williams. Univ. of Texas Press, Austin, 1959. 130 pp. $2.50.

American Petroleum Refining. H. S. Bell. Van Nostrand, Princeton, N.J., ed. 4, 1959. 547 pp. $12.50.

Aromatic Substitution. Nitration and halogenation. P. B. D. De La Mare and J. H. Ridd. Academic Press, New York, 1959. 259 pp. $9.

Asbestos. Its industrial applications. D. V. Rosato. Reinhold, New York; Chapman & Hall, London, 1959. 220 pp. $5.75.

Carcinogenesis by Ultraviolet Light. Harold F. Blum. Princeton Univ. Press, Princeton, N.J., 1959. 355 pp. $6.50.

Cell, Organism and Milieu. Dorothea Rudnick, Ed. Ronald Press, New York, 1959. 331 pp. $8. This volume includes the contributions to the 17th symposium of the Society for the study of Development and Growth. The theme for this symposium was centered around the concept of differentiation and growth in response to a changing chemical environment. The contributions include reviews and studies of tissue differentiation as affected by the biochemical environment, muscle cell models, tissue response to hormonal milieu, growth factors operating on plant tissues, and growth and differentiation in whole organisms in relation to chemical alterations in their environment.

Chemical Engineering Economics. Chaplin Tyler and C. H. Winter, Jr. McGraw-Hill, New York, ed. 4, 1959. 212 pp. $7.

Clinical Evaluation of New Drugs. S. O. Waife and Alvin P. Shapiro, Eds. Harper, New York, 1959. 233 pp. $7.50. Contents: pt. 1, "Principles of drug evaluation"; and pt. 2, "Clinical trials in practice." Contributors include W. B. Bean, H. K. Beecher, K. H. Beyer, Jr., Harry F. Dowling, J. L. Gabrilove, D. J. Ingle, N. S. Kline, L. Lasagna, T. E. Machella, P. Meier, E. L. Severinghaus, A. P. Shapiro, S. O. Waife, and S. Wolf.

Connective Tissue, Thrombosis, and Atherosclerosis. Proceedings of a conference. Irvine H. Page, Ed. Academic Press, New York, 1959. 326 pp. $9.50.

Continuous Analysis of Chemical Process Systems. Sidney Siggia. Wiley, New York; Chapman & Hall, London, 1959. 394 pp. $8.50.

Contributions to the Theory of Games. vol. 4. A. W. Tucker and R. D. Luce, Eds. Princeton Univ. Press, Princeton, N.J., 1959. 460 pp.

Educating the Gifted. A book of readings. Joseph L. French, Ed. Holt, New York, 1959. 570 pp.

Electrolyte Solutions. R. A. Robinson and R. H. Stokes. Academic Press, New York; Butterworths, London, 1959. 574 pp. $11.50.

Elements of Chordate Anatomy. Charles K. Weichert. McGraw-Hill, New York, ed. 2, 1959. 511 pp. $6.75.

An Experimental Inquiry into the Principles of Nutrition and the Digestive Process. John R. Young. Univ. of Illinois Press, Urbana, 1959. 75 pp. $2.50.

Fluctuation Phenomena in Semi-Conductors. A. Van Der Ziel. Academic Press, New York, Butterworths, London, 1959. 176 pp. $6.50.

Hot Organic Coatings. Raymond B. Seymour. Reinhold, New York; Chapman & Hall, London, 1959. 243 pp. $7.50.

Hypersonic Aerodynamics. Robert W. Truitt. Ronald Press, New York, 1959. 474 pp. $10.

Hyperstatic Structures. An introduction to the theory of statically indeterminate structures. vol 1. J. A. L. Matheson. Academic Press, New York; Butterworths, London, 1959. 489 pp. $15.50.

Individual Choice and Behavior. A theoretical analysis. R. Duncan Luce. Wiley, New York; Chapman & Hall, London, 1959. 165 pp. $5.95.

Induced Oxidation. W. P. Jorissen. Elsevier, Amsterdam, Netherlands, 1959 (order from Van Nostrand, Princeton, N.J.). 218 pp. $8.75.

Liquids and Liquid Mixtures. J. S. Rowlinson. Academic Press, New York; Butterworths, London, 1959. 370 pp. $12.

Medical Biology and Etruscan Origins. Ciba Foundation symposium. G. E. W. Wolstenholme and Cecila M. O'Connor. Little, Brown, Boston, 1959. 267 pp. $9.50.

Modern Aspects of Electrochemistry. No. 2. J. O'M. Bockris. Academic Press, New York; Butterworths, London, 1959. 426 pp. $13.

Qualitative Analysis and Electrolytic Solutions. Edward J. King. Harcourt, Brace, New York, 1959. 662 pp. $6.95.

Reports

Individuality of the Meromyosins

Abstract. Subtilisin, as well as trypsin and chymotrypsin, splits myosin into meromyosin-like components. Examination of the N- and C-terminal residues of the L-meromyosin-like products suggests that all three proteases produce identical L-meromyosins. It is proposed that the role of the enzymes is to break secondary bonds.

Gergely (*1*) and Perry (*2*) first showed that trypsin rapidly modified myosin to produce a water-soluble material with no loss of adenosine triphosphatase activity. Gergely (*3*) obtained two fractions, one soluble and the other insoluble at low ionic strength, most of the adenosine triphosphatase activity remaining in the soluble fraction. Mihalyi and Szent-Györgyi (*4*) showed that the reaction was monomolecular and that two distinct components were produced. Szent-Györgyi (*5*) separated and named the heavier component H-meromyosin (molecular weight, 230,000) and the lighter, L-meromyosin (molecular weight, 100,000) and also determined their physical properties. Gergely, Gouvea, and Karibian (*6*) obtained similar products, using chymotrypsin plus trypsin inhibitor, instead of trypsin. I found that a sample of subtilisin (*7*) also converted myosin into components resembling H- and L-meromyosin by means of a monomolecular reaction (*8*). The latter component could also be separated into ethanol-stable (L-meromyosin) and unstable fractions, as in the case of trypsin- and chymotrypsin-produced L-meromyosin (*9*). Electron micrographs of crystals of the subtilisin-produced L-meromyosin showed the typical banded structure with the bands 420 A apart. Recently Kominz has split myosin into two components by means of snake venom (*10*).

Laki (*11*) pointed out that the L-meromyosins should differ in detail, according to the specificity of the enzyme used, if their production is dependent upon the hydrolysis of certain peptide bonds in the original myosin. He quoted certain references to support this hypothesis (*10, 12*).

A detailed examination (*13*) by means of the Sanger technique (with fluorodinitrobenzene) of the N-terminal residues of the L-meromyosins produced by the action of trypsin, chymotrypsin (with trypsin inhibitor to inactivate any traces of trypsin) and subtilisin, for various times, has failed to reveal more than two equivalents per mole, and these are made up of traces of ten different N-terminal residues. However, it is possible to depolymerize the L-meromyosins under suitable conditions in 5*M* urea (*14*), and this results in approximately a tenfold increase in the N-terminal residues found. After 24 hours' treatment, with urea, fluorodinitrobenzene was added and stirred vigorously until it dissolved, and sodium bicarbonate was added to maintain $pH > 8$. After 4 hours the solution was thoroughly dialyzed and lyophilized. The results for the depolymerized L-meromyosins are given in Table 1 and are always the same, irrespective of the enzyme used. If the N-terminal residues are produced by hydrolysis, they would not *necessarily* differ with the enzyme used, unlike the C-terminal residues, but the probability of their remaining the same is small.

Treatment of the L-meromyosins with carboxypeptidase A in the presence of diisopropylfluorophosphate at 40°C (enzyme:substrate = 1:100; 0.6*M* KCl; 1-percent $NaHCO_3$; *p*H 8.3) for 15 minutes liberated aspartic acid, threonine, serine, alanine, glycine, valine, (iso)-leucine, phenylalanine, histidine, and tyrosine, the total being equivalent to 1 to 2 C-terminal residues per molecule of L-meromyosin. On depolymerization of L-meromyosin in urea solution, followed by carboxypeptidase treatment, approximately 20 C-terminal residues per molecule of L-meromyosin were obtained. That the acids listed above originated from the C-terminal residues was shown by the fact that similar results were obtained with the Akabori technique (*15*). Longer treatment of L-meromyosin with carboxypeptidase A resulted in a higher yield of the above-named acids. This was due to the fact that treatment at *p*H 8.3 alone was found to slowly dissociate L-meromyosin, and consequently the C-terminal residues of the subunits were eventually liberated by the carboxypeptidase A. Still further treatment liberated other non-C-terminal acids.

The Akabori technique was also used to determine the presence of C-terminal lysine residues. After a correction of 53 percent for decomposition during the hydrazinolysis (*16*) had been made, less than 0.1 equivalent of C-terminal lysine was found in a mole of trypsin-produced L-meromyosin and considerably less in chymotrypsin-produced L-meromyosin. There was no increase in these values on depolymerizing the L-meromyosins. This small amount of lysine from the trypsin-produced L-meromyosin was probably due to specific hydrolysis of the myosin by the trypsin and resultant adsorption of the C-terminal lysyl peptide material on the L-meromyosin.

Thus, although it is true that certain amino acids, which would be expected as a result of the enzyme specificity, appear in traces as C-terminal residues, it should be pointed out that, with the exception of lysine, they are present in all the L-meromyosins produced by different enzymes and only appear in amounts equivalent to one or more C-terminal residues when the L-meromyosins are depolymerized. It is suggested, therefore, that the proteases first modify the myosin by breaking secondary bonds, which are stable with respect to urea treatment, to produce the meromyosins, through activity somewhat similar to the "denaturase" action postulated by Linderstrøm-Lang (*17*). Only the final degradation phase is due to specific hydrolysis. This does not entirely rule out the possibility that a "trigger" mechanism is "fired" by the hydrolysis of

Table 1. N-terminal residues of depolymerized L-meromyosins. Average chain weight, 5000.

N-terminal residue	Equivalents/ 100,000 g (± 0.2 equivalents)
Aspartic acid	2
Glutamic acid	2
Threonine	1
Serine	2
Alanine	2
Glycine	1 or 2?
Valine	2
Isoleucine	2
Lysine	4
Arginine	2

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

one or more peptide bonds, resulting in the formation of the meromyosins containing latent N- and C-terminal residues which can be liberated by depolymerization in 5*M* urea solution. However, this is unlikely, as the operation of the "trigger" mechanism would vary according to the specificity of the protease used, and these details would probably be detected on comparison of the C-terminal residues.

Laki (*11*) concludes "that the meromyosins are the proteolytic split products of myosin and as such should not be considered as pre-existing subunits of myosin." However, he agrees that "since tracer studies show that the two fragments of myosin have different turnover rates [(*18*)], at least two subunits of some kind pre-existing in the muscle can be postulated." I would, therefore, like to draw attention to the work of Marshall and Holtzer (*19*), who used an immunological staining technique with the antibodies of myosin, L- and H-meromyosin. The areas of the sarcomere, stained by the antibodies of L- and H-meromyosin, were more than the length of a myosin molecule apart, suggesting that myosin is either dissociated into L- and H-meromyosin in the muscle fibrils or that the molecule is greatly extended (*20*).

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1 June 1959

Specific Action of Adenine as a Feedback Inhibitor of Purine Biosynthesis

Abstract. Purines can prevent the formation of aminoimidazole precursors which are accumulated by bacterial mutants genetically blocked in purine biosynthesis. If the block does not interfere with interconversions among adenine, guanine, hypoxanthine and xanthine, then any of the purines can act as a feedback inhibitor. If conversion of the other purines to adenine is prevented, then adenine becomes a specific requirement for inhibition; this indicates that feedback control operates at a level involving adenine or one of its congeners.

Auxotrophic mutants of bacteria that accumulate the substrates of their blocked reactions have been extremely useful for studying feedback control of biosynthetic processes. The formation of the precursor serves as an index of the potential capacity of the bacteria for *de novo* synthesis of the metabolite in question. In the case of purine biosynthesis, feedback inhibition has been studied at the level of several aminoimidazole intermediates accumulated by purine-requiring mutants. The formation of the ribotides of both 5-aminoimidazole and 5-amino-4-imidazolecarboxamide (AICA) (excreted as their respective ribosides) is prevented by those purines which can support the growth of the mutants (1, 2).

Nonproliferating suspensions of strain B-96/1, a mutant of *Escherichia coli* B, accumulate AICA because of a mutational impairment in transformylase activity. An additional, genetically unrelated, requirement for tryptophan allows the nonproliferating condition to be maintained when growth-promoting purines are added in the absence of tryptophan. Under these conditions, all purines which can serve as growth factors (adenine, hypoxanthine, xanthine, guanine, and isoguanine) cause a direct and immediate cessation of AICA formation (2). Half-maximal inhibition is obtained with as little as 0.02 to 0.04 μmole of any purine per milliliter. Since interconversions between the purines can proceed unhampered beyond the transformylase block in strain B-96/1, it was not known whether each of the various purines exerted a separate inhibition or whether there was only one inhibitory form to which the others could be converted.

In order to resolve this question, a system was required which contained an early block to allow for accumulation of precursors as well as an additional late block beyond the pivotal position of inosinic acid to prevent interconversions of the exogenously supplied purines. In addition, an unrelated deficiency in amino acid formation would be desirable to permit analysis under nonproliferating conditions. The chance isolation of strain B-94, another mutant of *Escherichia coli* B, provided these requirements. This mutant is lacking in adenylosuccinase, a bifunctional deacylase which is required for two separate functions in the biosynthesis of adenylic acid (*3*). One reaction involves the desuccinylation of SAICAR (*4*), the succinyl derivative of AICA-ribotide; the other involves a similar splitting of adenylosuccinic acid to yield adenylic acid. Consequently, loss of this enzyme results in (i) the accumulation of SAICAR (excreted as both riboside and ribotide in the proportion 85:15) and (ii) a block in the process by which inosinic acid is aminated to adenylic acid so that interconversions which lead to adenylic acid are prevented and a specific requirement for adenine is manifested. Strain B-94 also exhibits a growth requirement for arginine which is unrelated and genetically distinct from the adenylosuccinase deficiency.

Table 1. Comparison of the inhibitory action of purines on the formation of AICAR by strain B-96/1 and on SAICAR by strain B-94.

Purine	Amount required for 50% inhibition (μmole/ml)	
	AICAR (B-96/1)	SAICAR (B-94)
Adenine	0.02	0.03
Hypoxanthine	0.02	0.24
Guanine	0.04	7.20
Xanthine	0.03	> 10.00

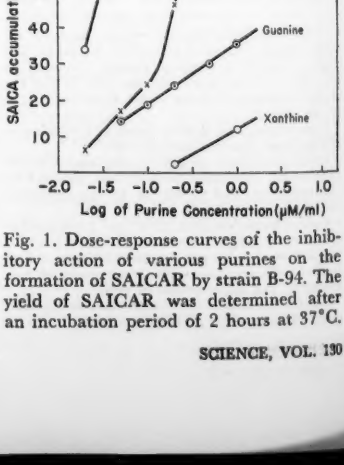

Fig. 1. Dose-response curves of the inhibitory action of various purines on the formation of SAICAR by strain B-94. The yield of SAICAR was determined after an incubation period of 2 hours at 37°C.

Accumulation of SAICAR and AICAR by nonproliferating suspensions of strains B-94 and B-96/1, respectively, was examined by methods previously described (*5*). Glucose and ammonium chloride served as the sources of carbon and nitrogen. The accumulated compounds were measured as diazotizable amines with special modifications (*3*) to distinguish between SAICA and AICA. In Table 1, the amounts of the purines required for a 50-percent inhibition of SAICAR formation in strain B-94 are compared with the amounts required for similar inhibition of AICAR formation in strain B-96/1. In the latter case, where interconversions are not impaired, there is no more than a twofold difference between any of the purines, but in strain B-94, where interconversions are restricted, only adenine, the specific growth factor for this strain, shows a comparable degree of inhibition. As can be seen in Fig. 1, hypoxanthine has only 0.1 the activity of adenine; guanine and xanthine are comparatively inactive. The inhibition obtained with higher concentrations of hypoxanthine could be due to a weak feedback action, or, more probably, to an indirect effect whereby available substrates are diverted from their *de novo* purpose. For example, in the conversion of hypoxanthine to adenylosuccinic acid, a process known to operate in strain B-94, two substrates must be used which are also required for the *de novo* formation of SAICAR; these are 5-phosphoribosyl-1-pyrophosphate (PRPP) and aspartic acid. Xanthine and guanine would effect only a diversion of PRPP, and hence even higher concentrations would be required for inhibition. Thus, two mechanisms may be operating—one, an indirect effect inherent in the artificiality of the system whereby exogenously proffered compounds may compete for substrates; the other, a direct feedback action, operative in vivo and specifically triggered by very small concentrations of adenine or one of its ribosylated congeners (*6*).

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27 April 1959

Dispersal of Fresh-Water Algae by Migratory Water Birds

Abstract. Many migratory water birds killed in Texas and Oklahoma contained viable fresh-water algae in the lower digestive tracts. Such birds are thought to play a significant role in the long-range dispersal of certain algae, particularly those species easily killed by desiccation.

Many fresh-water algae are distributed widely over entire continents, if not the world. How such forms are transported from one body of water to another is not well known, but the usual explanation has been that they are carried either by wind or on the feet, feathers, and bills of birds (*1*). As previously noted (*2*), neither method would be very effective in dispersing algae easily killed by desiccation, for example, the desmids. Such algae might be transported considerable distances without being subjected to desiccation if they could survive a passage through the alimentary canal of migratory birds (*3*). The observations reported here indicate that many fresh-water forms are able to do so.

Over a period of approximately one year, 25 different migratory waterfowl (126 birds) were shot from playas and fish-hatchery ponds in western Texas and south-central Oklahoma. Thirteen were discarded because of empty or shot-perforated large intestines. The birds were placed on ice as soon as they were killed, and later examined, usually within 1 to 3 hours. At that time one inch of gut from between the junction of the caecum and the cloaca was ligated and removed. Also an occasional sample was taken from the distal portion of one of the caeca. After the section of the intestine had been dipped in 70-percent ethyl alcohol to remove possible contaminants, one end was removed with sterile scissors, and the fecal contents were allowed to drop into a sterile flask of distilled water. A few minutes later 5 ml of this suspension was pipetted to a second flask containing autoclaved soil-water medium. This procedure was followed for each bird, yielding two sets of flasks. Both sets of flasks were then placed in a culture cabinet at 23°C under continuous artificial light for a period of 3 to 10 days. At the end of that time the contents were examined microscopically for living algae.

Viable algal cells were present in the lower digestive tract or caecum of one or more of the birds from each of the 25 genera examined. Viable algae were present in birds killed over both land and water. From such piscivorous genera as grebes, herons, kingfishers, and egrets only a few simple unicellular green algae of the "Chlorella type" and an occasional blue-green alga were obtained. A much greater variety of algae was found in ducks and bottom-feeding

Table 1. A comparison of the number and kinds of viable fresh-water algae recovered from the lower digestive tracts of some migratory water birds.

Bird	No. of birds examined	No. of algal genera present	Representative genera of algae*
Pied-bill grebe (*Podilymbus podiceps*)	9	2	
Green-winged teal (*Anas carolinensis*)	14	17	4, 5, 6, 7, 10, 11, 13, 14
Blue-winged teal (*Anas discors*)	5	14	3, 4, 5, 6, 10, 13
Shoveler (*Spatula clypeata*)	6	20	1, 2, 4, 5, 6, 8, 10, 13, 15
American coot (*Fulica americana*)	7	28	2, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15
Killdeer (*Charadrius vociferus*)	20	20	4, 5, 6, 7, 9, 10, 11, 13, 14, 15
Dowitcher (*Limnodromus griseus*)	9	20	1, 2, 3, 4, 5, 6, 7, 10, 13, 14, 15
American avocet (*Recurvirostra americana*)	4	15	1, 5, 6, 10, 12, 13, 15
Wilson's phalarope (*Steganopus tricolor*)	2	11	5, 6, 8, 9, 10, 13
Belted kingfisher (*Megaceryle alcyon*)	2	1	

* Key: 1, *Gonium*; 2, *Pandorina*; 3, *Eudorina*; 4, *Oedogonium*; 5, *Pediastrum*; 6, *Scenedesmus*; 7, *Spirogyra*; 8, *Closterium*; 9, *Penium*; 10, *Cosmarium*; 11, *Staurastrum*; 12, *Phacus*; 13, Naviculoid diatoms; 14, *Merismopedia*; 15, *Arthrospira*.

shore birds. In this latter group there were a number of fresh-water forms characteristic of the ponds of the region, in addition to the ubiquitous unicellular green algae. Some of the more interesting algae found in a representative group of birds are listed in Table 1.

As a rule, more algae were present in birds shot during the spring than at any other time of the year. This probably reflected the greater diversity of algae normally present in the playas at that season. A scarcity of seeds and insects also may have caused the birds to ingest increased amounts of algae.

A microscopic examination of fecal material shortly after it was removed from the birds disclosed that *Gonium, Pandorina,* and at least four genera of desmids had passed through the alimentary canal as vegetative cells. Since many blue-green algae as well as a number of smaller unicellular green algae have no specialized resting stages they also must have passed through as vegetative cells. Viable filamentous green algae were never observed in any part of the digestive tract beyond the gizzard, although partially digested cells were often present. Filaments of *Spirogyra* and *Oedogonium,* present in the flasks after approximately one week, probably developed from zygotes.

Attempts to germinate intact *Chara* zygotes found throughout the guts of a coot and a blue-winged teal were unsuccessful. Neither motile yellow-green algae nor dinoflagellates were ever observed in cultures from any of the birds. The afore-mentioned three groups are known to have relatively complex cultural requirements, and the possibility cannot be ruled out that failure was due to unsuitable media or environmental conditions.

From a consideration of the rate of movement through the alimentary tract (*4*) and flying speed (*5*) of common migratory water birds, it seems reasonable to conclude that many fresh-water algae can be carried easily between lakes 100 to 150 miles apart. Cells or colonies in the caecum may be carried several times this distance.

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17 April 1959

Effect of Light on Motility, Life-Span, and Respiration of Bovine Spermatozoa

Abstract. Exposure to light of bovine spermatozoa suspended in various media results in a progressive decline in metabolic activity followed by the premature death of the cells. The inhibitory and spermicidal effects of visible light resemble a photodynamic action; the photosensitizer is an intrinsic component of the cell.

The deleterious effects of short-wavelength radiation on spermatozoa have been examined in some detail by a number of workers (*1*). Wells and Giese (*2*), studying photoreactivation of ultraviolet-irradiated sperm of the purple sea urchin *Strongylocentrotus purpuratus,* observed that visible light was also very harmful to these cells, immotilizing them and rendering them incapable of fertilizing normal eggs. A later investigation (*3*) showed that glycine exerted a protective effect during exposure to visible light.

With the development of an artificial medium in which bovine spermatozoa can be maintained at room temperatures in a physiologically active state in vitro for several days (*4*), it has become possible to study experimentally the response of these cells to visible light.

The collection and processing of bovine semen was carried out essentially as described by Norman *et al.* (*4*). The sperm were suspended in a modified coconut-milk extender which contained, in final concentration, 15 percent coconut milk, 2.16 percent sodium citrate dihydrate, 0.068 percent dihydrostreptomycin sulfate, 0.031 percent sodium penicillin, 0.3 percent sulfanilamide, and 2.5 units of mycostatin per milliliter. The final concentration of the cells, determined with a hemocytometer, was between 10×10^6 and 15×10^6 cells per milliliter. Plastic vials containing the cell suspension were illuminated for varying periods on a glass plate 7 mm thick, placed 33 cm from a bank of two 40-watt white fluorescent bulbs. These lamps have a spectral range from 0.4 to 0.7 μ (*5*). The light intensity at the level of the sample vials was 300 ft-ca, as measured with a model 756 Weston illumination meter, and the ambient temperature was maintained at 26° ± 2°C during the experiment. The parameters used to determine the light sensitivity of the cells were the percentage of dead cells, as measured by the differential staining method of Campbell, Dott, and Glover (*6*); motility; and oxygen consumption, expressed as Z_{O_2}. Appropriate controls were kept in the dark.

Table 1 is a summary of the results of three replicate experiments on continuous illumination of the spermatozoa. These data indicate that exposure to light results in concomitant loss of mo-

Table 2. Effect of light on spermatozoa suspended in various media. Light intensity, 1400 ft-ca.

Exposure (hr)	Dead cells %		Motility	
	Light	Dark	Light	Dark
Krebs-Ringer phosphate				
10	56	30	2.0	3.5
60	63	39	0.5	2.5
*Krebs-Ringer phosphate plus antibiotics**				
10	74	38	0	3.5
60	100	52	0	3.0
0.85% NaCl				
10	89	32	0	4.0
60	100	68	0	2.5
0.85% NaCl plus antibiotics				
10	88	32	0	3.5
60	100	100	0	0
15% Coconut milk in Krebs-Ringer plus antibiotics				
10	51	22	0	4.5
60	100	34	0	3.0
Skim milk†				
24			0	3.0
60	95	36	0	2.5

* Same as in coconut-milk extender.
† Temperature, 5°C.

Table 1. Effect of light on spermatozoa suspended in various media. Light intensity, 300 ft-ca. Values are averages for three replicate experiments. Temperature during exposure, 26° ± 2°C.

Exposure time (hr)	Dead cells (%)		Motility*		Z_{O_2}	
	Light	Dark	Light	Dark	Light	Dark
Coconut-milk extender (10×10^6 *to* 15×10^6 *cells/ml*)						
24	50	32	0	3.0	0.4	5.34
72	100	36	0	3.0		
Coconut-milk extender and catalase (10 mg%) (10×10^6 *to* 15×10^6 *cells/ml*)						
24	36		2.0			
Coconut-milk extender (2×10^8 *cells/ml*)						
24	32	36	2.5	3.5		
72	73	31	1.0	3.0	0.0	3.5

* Motility ratings: 5.0, excellent; 4.0, good; 3.0, fair; 2.0, poor; 1.0, vibratory; 0.0, nonmotile.

tility and decrease in respiration of the sperm, followed by death of the cells. Apparently, with a more concentrated suspension of cells, sensitization is prolonged. The reason for this is not known at the present time. The protection afforded by the addition of catalase to the medium indicates that a photochemical oxidation producing H_2O_2 is occurring as a result of the radiation.

In order that this phenomenon may be defined as photodynamic action, it is necessary that there be some fluorescent substance present which can absorb radiant energy (*7*). The activated sensitizer transfers its energy to an acceptor, presumably a cellular protein, which then undergoes oxidation. To determine the source of the photosensitive agent, the effect of light on spermatozoa suspended in various media was tested. Since these cells will not survive at room temperature for a prolonged period of time, except in coconut-milk extender, it was necessary to modify slightly the experimental design and expose the samples to a higher light intensity (1400 ft-ca) for a shorter time. The results are shown in Table 2. The data clearly reveal that the photosensitive agent is not a constituent of any of the media tested or of the antibiotics which supplement them, although the latter may enhance the photochemical reaction. Comparison of Tables 1 and 2 indicates that the effect of radiation—presumably an oxidative process—is in accord with the Bunsen-Roscoe reciprocity law (*7*). Further, the effect is independent of temperature, as demonstrated by the results with the skim-milk diluent at 5°C. These are characteristics usually identified with a photosensitized oxidation (*7*).

On this basis, then, it can be concluded that there is a photosensitizer present within the sperm itself and that the radiation affects the cell directly. Calcutt (*8*), working with *Paramecium*, suggests that light has a direct action upon the test material, inducing a cellular change which facilities the photodynamic response. This phenomenon apparently involves cytoplasmic damage, as compared with the nuclear effects of ultraviolet radiation (*9*).

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9. Preliminary attempts to delineate the light source into narrower spectral bands indicates that the photosensitive agent within the sperm has a maximal absorption in the blue. We thank I. D. Porterfield of the dairy husbandry department for furnishing us with bovine semen, the College of Agriculture, West Virginia University, for financial support, and C. E. Johnson for his technical assistance.

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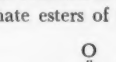
Mechanism of Enzyme Inhibition by Phosphate Esters

Abstract. A theory for the rapid specific reaction of certain phosphorous-containing esters with many proteolytic enzymes based on the ability of phosphorous to form one additional bond relative to carbon is presented. A stable tetrahedral phosphate ester is compared with a labile tetrahedral orthocarbonyl ester and a relatively stable pentagonal enzyme-phosphate ester complex is compared with a pentagonal enzyme-carbonyl substrate complex. The latter complex is assumed to be the transition state in the enzyme-catalyzed reaction. If the theory is correct, it opens up the possibility of studying intermediates and transition states from the known structures of chemical inhibitors.

The specific reaction of a group of organic phosphate esters of the type



where R is an alkyl group and R′ an alkyl or alkoxy group, with a class of esterases and phosphoglucomutases has long been known. Some pertinent chemical facts concerning the inhibition reaction are: (i) The reaction products are the degraded fragment (X) and the enzyme, phosphorylated on the hydroxyl group of a serine residue (*1*). (ii) The reaction is stoichiometric with the number of enzymatic sites and not with the total number of serine residues. (iii) The reaction proceeds with a high velocity with all the enzymes for which the stoichiometric relationship holds. (iv) The phosphorylated enzyme is catalytically inactive.

The extreme velocity of the inhibition reaction contrasts with the rates of homogeneous solution reactions of the phosphate esters. Tetraethylpyrophosphate, for example, is remarkably stable in neutral aqueous solutions. Even di-isopropyl-phosphofluoridate is much more stable than acetic anhydride (*2*). Nonetheless, it reacts much more rapidly and specifically with suitable esterases.

In this report we wish to suggest that the action of the phosphate esters differs from that of most other enzyme inhibitors in that it is the unstable transition state of the enzyme-substrate complex which is imitated by the inhibitor in one of its stable combinations with the enzyme. More frequently, it is assumed that inhibitor action is effected by imitation of either the substrate itself or a *stable* combination of substrate with enzyme.

If our postulate is correct, one can understand why the side group specificity of the inhibitors is so different from

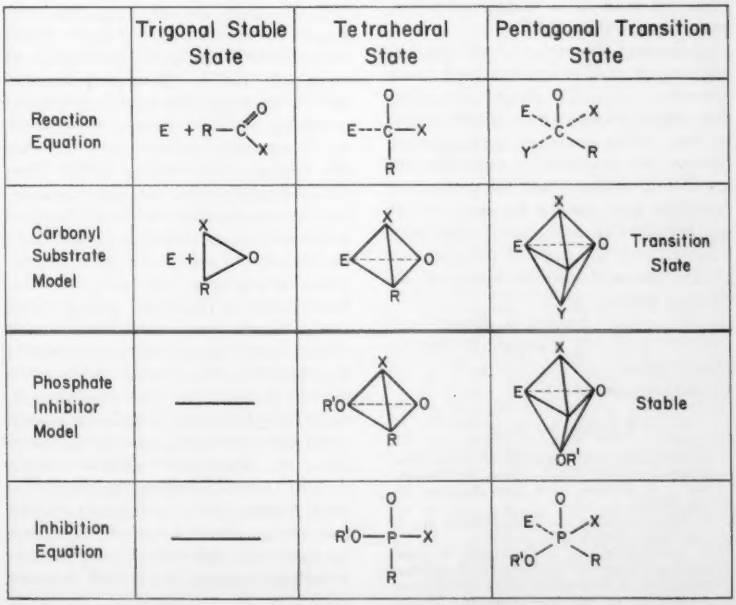
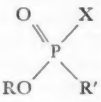


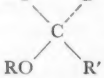
Fig. 1. Stereochemical representation of enzyme action.

that of the natural substrates of the enzyme. It is presumably hydrogen bonding and electrostatic interactions at or close to the ester linkage which makes the enzyme combine so much more strongly with the transition state than with the substrate, which in turn causes the lowering of the activation free energy for reaction. Owing to the stability of phosphorous compounds with one more covalent bond than can occur in analogous carbon compounds, this larger interaction energy is available for binding the inhibitor molecule.

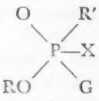
The structure of most phosphoric esters is of the kind



This imitates rather closely the presumed intermediate in the S_{N2} hydrolysis of a related ester



where *B* is a basic group. On the other hand, covalency of 5 is quite common among phosphorus compounds, and a metastable intermediate



where G is a group from the enzyme, might also imitate quite closely the transition state for a Walden inversion, as is illustrated in the Fig. 1.

A detailed discussion of the mechanism of esterase action has been given elsewhere (*3*). It should be clear that phosphorus esters are ideally suited to form stable structures corresponding both to the proposed enzyme-substrate tetrahedral complex and the pentagonal transition state for the reaction (*4*). If our speculations are correct, they may make possible the study of the geometry of the activated state by means of inhibition studies (*5*).

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4. If the transition-state is tetrahedral rather than pentagonal the above arguments apply with only minor modifications.
5. We are grateful to the Study Section in Biophysics and Biophysical Chemistry of the National Institutes of Health for the opportunity jointly to participate in their program at Boulder, Colo., during the summer of 1958. One of us (S.A.B.) is indebted to the National Institute of Mental Health, Bethesda, Md., for sponsoring attendance at the program.

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Immunization of Mice against Toxic Doses of Homologous Elementary Bodies of Trachoma

Abstract. Death of mice occurs 2 to 8 hours after intravenous inoculation of concentrated viable elementary bodies of trachoma. Toxic death can be prevented by vaccinating the mice with concentrated suspensions of homologous strains inactivated by formalin or phenol. Judged by toxic challenges, at least two antigenically distinct types of elementary bodies of trachoma occur in Saudi Arabia and Egypt.

The relationship of elementary body viruses to the classical syndrome trachoma, although much disputed in the past, has been more firmly established by the recent findings of Tang *et al.* (*1*) and Collier *et al.* (*2, 3*). These reports indicate that several properties are shared by the elementary body viruses derived from conjunctival scrapings of trachoma cases in China and Gambia. Before attempts are made to prevent trachoma by immunization procedures, it is important to determine whether the strains of elementary bodies from different regions are all alike antigenically or whether there are multiple types which are immunologically distinct from one another. Toxicity for mice was reported as a property of strain SA-1, isolated from a trachoma patient from Hofuf, Saudi Arabia (*4*). Subsequently several other strains from the Middle East have been found toxic for mice (*5*) and the phenomenon thus offers a possibility for comparison of different strains. Since the elementary bodies of trachoma share the heat-stable common antigen derived from psittacosis-lymphogranuloma viruses (*2, 5*), it should be noted that certain of the latter are also toxic for mice and that several antigenic and pathologic patterns have been reported (*6, 7*).

Eight experiments were performed which involved vaccination and subsequent toxic challenges of white mice. The vaccines were prepared from yolk sacs of chick embryos which were harvested approximately 7 days after infection with the various strains. Vaccines and normal yolk sac control materials were administered intra-abdominally, and the mice were challenged at various intervals thereafter by the intravenous inoculation of viable suspensions of elementary bodies adjusted in concentration such that each mouse received one certainly fatal dose. There were two types of controls for the vaccines: (i) normal yolk sac suspensions, and (ii) 0.85 percent NaCl solution. The vaccines and control solutions were given on the basis of 0.2 ml/10 g body weight of the mice. The strains of elementary bodies were SA-1, SA-2, SA-5, and Egypt-2, derived from trachoma patients in Saudi Arabia and Egypt (*5*).

The suspensions for challenge and for vaccines were prepared as follows: chick embryos, after 6 to 8 days of incubation, were inoculated with infectious yolk sac suspensions in dosages adjusted to cause death of half the eggs about 7 days later, when the yolk sacs of surviving embryos were harvested. The inocula consisted of material derived from the 5th to 10th egg passage levels of the different strains involved. The yolk sacs were thoroughly mixed mechanically and stored at −60°C. Purification and concentration of the elementary bodies were accomplished by two cycles of centrifugation at +4°C; each cycle consisted of 1500 rev/min for 15 minutes to eliminate gross particles, followed by 5000 rev/min for 60 minutes to reduce the amounts of protein and lipids. Exposure to celite (*7*) before the second cycle was begun was also included in the procedure.

After the second high-speed run, the sediments were resuspended in one-fourth the volume of the original yolk sacs. If the material was to be used for challenge, the suspending material was sucrose PG (*8*). If the material was to be made into vaccine, the suspending medium was phosphate saline buffered to *p*H 7.2. The suspensions of elementary bodies were shown to be toxic for white mice; they were then shell frozen and stored at −60°C until ready for use. In the preparation of vaccines, the suspensions were thawed and mixed with an equal quantity of freshly prepared 0.4 percent formalin, or 0.8 percent phenol, in buffered saline. One lot of SA-2 vaccine was extracted with ether; this extraction replaced the step involving celite. After overnight storage at +4°C, each vaccine was shown to be free of bacteria by appropriate tests; the

presence of viable elementary bodies was ruled out by four successive negative transfers in chick embryos. The control materials from normal yolk sacs were prepared exactly as were those containing infectious strains. The vaccines were diluted with sterile saline just before inoculation to make the concentration of the elementary bodies equivalent to the amount in 1.0 g of yolk sac at the time of harvest; the final concentration of the inactivating reagents in the different batches was thus reduced, in the case of formalin, to 0.1 percent, and in the case of phenol, to 0.2 percent. On the basis of parallel titrations, it was estimated that each gram of infected yolk sac at the time of harvest contained approximately 12 fatal toxic doses for mice, or 10^6 infectious doses for chick embryos.

Preliminary experiments were performed with a formalin-inactivated vaccine of 10 percent yolk sac prepared by simple ether extraction; the challenge was a crude suspension of toxic yolk sac in sucrose PG. The concentration of elementary bodies in the vaccine was inadequate under such circumstances to provide immunity against toxic challenge. Furthermore, in the interval from 10 to 55 minutes after inoculation of the challenge, many of the mice died with signs of anaphylaxis. Although purification and concentration of the challenge material reduced the numbers of mice which succumbed in anaphylaxis, the phenomenon continued to be important in the experiments, since 57 vaccinated mice died of anaphylaxis, out of the total number challenged, 217. The deaths were scattered through all the different groups except the saline controls.

Among the mice which were given normal yolk sac suspensions as a control vaccine, there were 29 anaphylactic deaths in the course of the subsequent toxic challenge out of the total of 88 challenged. Just preceding anaphylactic death the mice had labored, gasping respiration, often accompanied by blood-tinged nasal discharge. At autopsy the lungs were distended and the cut surfaces showed frothy exudate. Anaphylactic death did not occur in any of the 55 mice in the saline control groups which were challenged in the same experiments. Thus the anaphylactic deaths, in the interval from 10 to 55 minutes after challenge, were easily distinguishable from the deaths due to toxic properties of the elementary bodies. The latter regularly occurred from 2 to 8 hours after challenge, without attendant signs of respiratory distress; the characteristic feature post mortem was the hemorrhagic appearance of the upper small intestine. In the report below, the anaphylactic deaths have been eliminated from the tabulations.

Table 1. Immunization of mice against toxic challenge. Ratios, survivors to total (see text regarding anaphylactic deaths). Summary of eight experiments.

Vaccination schedule	Two doses, 0* and 7 days	Three doses, 0*, 7, and 21 days					
Day of challenge Challenge strain	17th, 20th SA-2	28th, 28th, 29th SA-2	29th SA-5	30th Eg-2	30th SA-1	Total Homologous	Total Heterologous
Vaccine	†	‡					
SA-2 formalin	6/11	18/21		0/10	0/9	18/21	0/19
SA-2 phenol	4/7	5/5				5/5	
SA-2 ether and formalin	5/10	3/3				3/3	
Total	15/28	26/29				26/29	0/19
SA-1 formalin		0/15		4/5	0/3	0/3	4/20
SA-5 formalin		1/7	7/7	0/10	0/8	7/7	1/25
Eg-2 formalin		0/3	7/10	7/7	3/5	7/7	10/18
Total						14/17	15/63
Control							
Normal yolk sac, formalin	0/11	0/14		0/6	0/4	0/24	
Normal yolk sac, phenol	0/10	0/6				0/6	
Saline only	0/11	1/18	1/8	0/9	0/9	2/44	
Totals	0/32					2/74	

* Mice were weaned approximately 3 weeks after birth. "Zero day" indicates the beginning of the tests, which occurred within 1 day of weaning.
† Summary of results of experiments 1 and 2.
‡ Summary of results of experiments 3, 4, and 5.

The data from eight different experiments are assembled in Table 1. Approximately half of the mice (15 of 28) which received two doses of the SA-2 vaccines were immune to the lethal toxic dose of SA-2 elementary bodies; after a third dose of vaccine at 21 days the survival rate was considerably higher (26 of 29). The data further suggest that there was no important difference between the SA-2 vaccines prepared with formalin, phenol, or ether extraction plus formalin. Formalin-inactivated vaccines of SA-1, SA-5, and Egypt-2 did not protect against SA-2 challenge.

When the other strains were used for challenge, none the the SA-2 vaccinated mice was protected (no survivors of 19 challenged). Vaccine prepared from Egypt-2 gave partial protection against toxic challenges of SA-5 and SA-1, and complete protection against Egypt-2. The results suggest that there may be an antigenic overlap among the strains SA-1, SA-5, and Egypt-2. The controls were satisfactory, there being only 2 survivors out of 106 challenged.

These experiments indicate that it is possible to protect mice against toxic death by three doses of concentrated suspensions of homologous trachoma elementary bodies, inactivated by formalin or phenol. Although the tests were complicated by anaphylactic phenomena, the method can be applied to one of the major problems in research on trachoma, namely, to determine how many different antigenic types or groups of elementary body viruses are involved in the etiology of clinical trachoma. Our findings suggest that there are at least two types currently prevalent in Saudi Arabia and Egypt (*10*).

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28 July 1959

Sublimation Freeze-Drying without Vacuum

Abstract. Analysis of the freeze-drying procedure shows that the passage of water vapor from the drying boundary through the dried shell is facilitated primarily by the vapor pressure gradient rather than by the absolute pressure of the system. This is experimentally confirmed, and a device for freeze-drying at atmospheric pressure is described.

The conventional freeze-drying apparatus embodies a specimen chamber with some means of maintaining constant specimen temperature, a pumping system to produce a high vacuum in the specimen chamber, and either a cold trap or a desiccant to remove water vapor evolved from the specimen. The maintenance of a predetermined specimen temperature is necessary to insure that the specimen receives sufficient heat to support sublimation but that its temperature does not rise sufficiently to permit ice-crystal growth or even melting. The purpose of the cold trap or desiccant is to remove from the system water vapor released by the specimen and to prevent the condensation of water in the vacuum pump. However, the function of the high vacuum is not as self-evident as it might at first appear to be, and studies of the mechanism of freeze-drying have led us to means by which the vacuum system may be altogether eliminated.

When a biological specimen freezes, most of the water is removed from solution and isolated in ice crystals, the size of which depends on the rate of freezing. The purpose of subsequent freeze-drying is to remove the water from these crystals without permitting further changes in the specimen. The rate at which water molecules leave the crystal is dependent solely on their temperature. The proportion which return to the crystal depends on the concentration of the surrounding vapor. The net removal of water from the crystal thus depends on the effectiveness with which vapor is prevented from returning to the crystal.

There are two major obstacles to the removal of water vapor: the resistance of the already dried shell of the specimen and any impediment to the transfer of vapor molecules from the specimen surface to the vapor trap. Both theoretically (*1*), and as shown by the experiments described below, the resistance to diffusion created by the dried specimen shell is very great—so great, in fact, that the presence or absence of gas molecules in the spaces vacated by ice crystals is of secondary importance. The factors determining the rate of diffusion of water vapor through this shell are then, (i) rate of vapor production (specimen temperature), (ii) resistance of the dried layer, and (iii) water-vapor pressure at the specimen surface. Since specimen temperature and size are fixed by other considerations, the primary goal in freeze-drying is the efficient removal of water vapor from the specimen surface.

In a system employing a cold trap or desiccant, the purpose of the vacuum is to facilitate the passage of water vapor from the specimen surface to the trap by reducing the number of gas collisions made en route. Ideally, the trap should surround the specimen, and the mean free path should be long enough so that most vapor molecules can travel directly to the trap without collision. Since the rate of passage of water vapor through the dried specimen shell is controlled primarily by water-vapor pressure at the surface of the specimen rather than by total gas pressure, prompt removal of water vapor once it reaches the specimen surface is mandatory for efficient drying. The vacuum system is useful only to facilitate the transfer of vapor to a vapor trap.

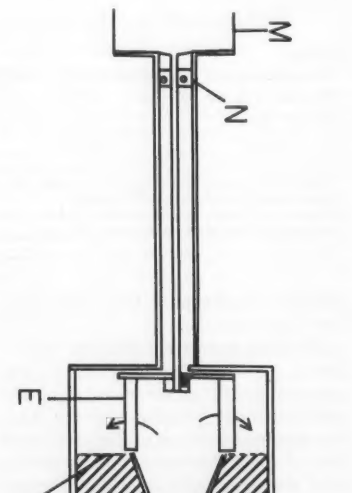

Fig. 1. Device for freeze-drying at atmospheric pressure.

From the foregoing discussion it is clear that any means of removing water vapor from the specimen surface should be nearly as satisfactory as the high-vacuum approach. To this end we have employed dry air blown past the specimen to sweep away water-vapor molecules as they reach the surface of the specimen. A similar approach has been reported by Treffenberg (*2*), who employed a slow transfer through the specimen chamber but in conjunction with reduced pressure. At atmospheric pressure efficiency of the system is improved by increasing the rate of air transfer past the specimen to reduce the thickness of the boundary layer, which will be rich in water vapor.

The apparatus employed is a recirculating system in which air is blown sequentially through a desiccant and across the specimen. The details of construction are shown in Fig. 1. The apparatus is basically a cylinder with a tube running down its center. The specimen is located in a basket *G*, inserted through a port into the central tube. After insertion the system is sealed by stopper *H*. A conventional squirrel-cage blower *E* draws air through the central tube past the specimen and back through the desiccant *D*, which fills the annular space surrounding the central tube. The motor *M* drives the blower through a sealed bearing *N* so that the entire system, once assembled, is completely airtight. The desiccant, retained by screens at *C* and *B*, is a material of very low vapor pressure and high water capacity, properties essential for this purpose (*3*). The apparatus can either be placed in a cold chamber or wrapped with tubing and cooled by a conventional refrigeration system. A thermocouple at *F* permits accurate control of air temperature.

Our standard specimen for the evaluation of freeze-drying techniques is a cube of mouse kidney measuring 2 mm on a side, fresh-frozen by immersion in liquid propane at −195°C and dried at −30°C. A higher temperature of drying permits excessive ice-crystal growth, which impairs the histological integrity of the specimen. From our experience and that of others (*4*), such a specimen requires a minimum of 6 hours' drying time in an efficiently designed vacuum freeze-drying system; a shorter period of time leaves the specimen undried at the center. Standard specimens desiccated in the dry-air device described

above can be dried in 8 hours. Following this drying period the specimen is removed to a vacuum chamber for embedding in paraffin. The quality of the results, in terms of histological detail, appears equivalent to that of results obtained by the conventional vacuum freeze-drying approach. The efficiency of this method compares favorably with the best reported vacuum freeze-drying and is substantially superior to that of devices which do not have the cold trap in line of sight from the specimen.

The mechanical simplicity achieved through elimination of vacuum pumps and use of a vacuum-tight system is considerable. An additional advantage of this approach, however, appears to be in situations where a number of specimens are to be dried simultaneously, where the many specimens and their supports constitute physical obstacles which diminish the effectiveness of the vacuum system by preventing straight-line passage of vapor to the trap. Above all, these experiments (*5*) confirm the supposition that passage of vapor through the dried specimen shell is primarily a matter of vapor pressure gradient rather than of total pressure in the system.

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5. I wish to acknowledge the skilled assistance of Raymond Long in the design and construction of the device described in this report.

24 April 1959

Photodynamic Inactivation of Monkey Kidney Cell Monolayers

Abstract. Monkey kidney cell monolayers exposed to white light in the presence of neutral red (1:40,000) undergo degeneration within 24 hours after exposure.

This communication concerns the effect of white light on monkey kidney cell monolayer cultures in the presence of the vital stain neutral red. In the course of attempts to photoreactivate ultraviolet-light-inactivated monkey kidney cell monolayers grown in 100-mm petri dishes, it was observed that unirradiated monolayers, when exposed to white light in the presence of the vital stain neutral red (1:40,000), degenerate within 24 hours after exposure. Similar plates exposed to the same light for the same time period, but in the absence of the neutral red, showed no ill effects from the exposure. Neutral red applied to the cells after exposure to the white light did not produce cell degeneration and was picked up by the cytoplasm as in unexposed cells. If the light was first passed through a solution of neutral red (1:40,000), the particular wavelengths of light responsible for the damage were filtered out, and damage to the cells was prevented. However, when methylene blue (1:10,000) or trypan blue (1:10,000) were used as filters, damage occurred as it did with unfiltered white light. The results are summarized in Table 1.

Table 1. Tissue degeneration with various dyes applied to the culture.

Time of exposure (min)	Tissue degeneration*			
	No dye	Neutral red (1:40,000)	Trypan blue (1:10,000)	Methylene blue (1:10,000)
0	0	0	0	0
2.5	0	0	†	†
5.0	0	0	†	†
10	0	1	0	0
20	0	3	†	†
30	0	4	0	0
60	0	4	0	0
90	0	4	†	†
Light filtered through trypan blue				
60		4		
Light filtered through methylene blue				
60		4		
Light filtered through neutral red				
60		0		

* Degeneration: 100 percent, 4; 50 to 75 percent, 3; 0 to 25 percent, 1; none, 0.
† Not determined.

The source of the white light was a bank of three 20-watt fluorescent bulbs at a distance of 15 cm. The light was filtered through a 3-cm solution of 1-percent copper chloride, and the temperature of the air above the solution did not rise above 38° to 39°C.

It is suggested that perhaps one cause for the occasional degeneration of monkey kidney monolayers or for the loss in plaque count (*1*) seen after the addition of the nutrient-agar–neutral-red mixture used in the Dulbecco Plaque Technique is inadvertent exposure to white light. It is evident from these findings that in the presence of neutral red, the exposure of the tissue to white light should be kept to a minimm.

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* Fellow of the National Foundation for Infantile Paralysis, Inc.
† Public Health Service senior research fellow (SF-218); aided in part by an Atomic Energy Commission contract.

6 April 1959

Effects of Differential Infantile Handling upon Weight Gain and Mortality in the Rat and Mouse

Abstract. Animals were handled during ages 1 to 10, 11 to 20, or 1 to 20 days, or were nonhandled controls. Animals handled for 20 days weighed the most in adulthood, while the controls weighed the least. Animals handled on days 1 to 10 survived food and water deprivation the longest of any group. Mice handled for 20 days died earlier than controls, while the reverse was true for the rat.

The general procedure followed in studying the effects of infantile experience upon adult behavior has been to stimulate the organism from birth until weaning and then test for effects of the stimulation later in life. Since the rat and mouse undergo tremendous developmental changes during the pre-weaning period, it is likely that the same stimulation affects the organisms differently at different developmental stages. This is suggested by Scott's critical period hypothesis (*1*) and by the work of Levine and Lewis (*2*). Therefore, if animals are stimulated only during certain parts of the pre-weaning period, the stimulation may interact with maturational processes which are at different stages of development to differentially modify adult behavior.

Complete litters of rats descended from the Harvard Wistar strain, and C57BL/10Sc mice were randomly assigned to one of the following infantile experience groups: handled on days 1 to 10, handled on days 11 to 20, handled on days 1 to 20, and nonhandled controls (*3*). At least two litters were used per experimental treatment. Handling consisted of removing the pups from the home cage, placing them in a container (a 1-gal can filled with sawdust for the rat, and a wooden mouse box for the mouse) where they remained for 3 minutes, and then returning them to the home cage. This procedure was followed once daily on the appropriate days. All animals were weaned at 21 days and reared thereafter with like-sexed members of their own litter in small groups. Food and water were always available. At 69 days the rats were weighed and placed on total food and water deprivation in individual cages. The same was done with the mice at 54 days. All animals had received 10 days of testing of avoidance learning just prior to this. Hours until death occurred were recorded.

The group means for weight and mortality for both species are presented in Table 1. The data were analyzed in a 2×2 factorial design: presence or absence of handling on days 1 to 10 was one factor, while presence or absence of handling on days 11 to 20 was the

Table 1. Mean weight (in grams) and survival time (in hours) for the rat and mouse as a function of infantile handling.

Days on which handled	Weight	Survival time	No. of animals
	Rat		
None	166.79	173.50	16
1 to 10	191.33	229.58	12
11 to 20	176.77	223.92	13
1 to 20	194.12	199.60	15
	Mouse		
None	17.14	90.47	17
1 to 10	18.81	95.00	10
11 to 20	19.22	90.31	16
1 to 20	19.87	72.83	12

second factor. This analysis permits the evaluation of the interaction between the two factors.

Weight. For both species a monotonic relationship is found between amount of handling in infancy and weight in later life. The animals handled for 20 days were the heaviest, while the controls were the lightest. Tests of significance showed that rats handled during the first 10 days of life (groups handled on days 1 to 10 and 1 to 20) weighed significantly more than the two groups not handled at this time ($P < .05$). The same finding was obtained with the mouse ($P < .01$). In addition, the presence of handling during the second 10 days of life also led to a significant increase in body weight for the mouse ($P < .01$). In neither species was the interaction significant ($F < 1.0$ in both analyses). We conclude, therefore, that for both species the effects of handling during the first and second 10 days of life affect later body weight in an additive manner, with the presence of handling during the first 10 days bringing about a significant weight gain.

Mortality. For both species a *non*monotonic relationship is found between amount of handling in infancy and number of hours of survival in later life. For both the rat and mouse the interaction between presence or absence of handling during the first and second 10 days is significant beyond the .01 level. Inspection of Table 1 indicates that the reason for the significant interaction is that the animals which were handled on days 1 to 10 lived the longest, while those handled on days 1 to 20 died quite early. A test for trend, using the control group, the group handled on days 1 to 10, and the group handled on days 1 to 20, showed a significant quadratic (curvilinear) function beyond the .01 level for both species. We conclude, therefore, that handling during days 1 to 10 will lead to longer survival under total food and water deprivation but that lack of handling or prolonged handling will reduce survival time.

As one of us has reported elsewhere (*4*), the mouse data may be biased because of significantly differential "spontaneous" deaths which occurred between ages 28 and 35 days. That this is not a major bias is shown by a recent study by Levine and Cohen (*5*), who handled DBA/2 mice for the first 24 days of life and then injected leukemia virus into the experimental animals and nonhandled controls at about 50 days. They found that their handled mice died significantly earlier than the controls, which is consistent with our findings that the mice handled on days 1 to 20 died earlier than control mice. Our data for rats are also consistent with the findings of Levine and Otis (*6*), who reported a significantly lower proportion of deaths for rats handled for the first 20 days of life than for controls when both groups were placed on 120 hours of food and water deprivation.

Thus we see that when mice and rats are given 20 or more days of infantile handling the rats will survive longer than their controls while the reverse is true for the mice. It appears, therefore, that the same physical stimulation has a more severe effect upon the mouse. Though these two species differ in many respects, one of the outstanding differences between the C57BL/10Sc mouse and the albino rat is that the mouse is a more rapidly developing organism. This suggests the hypothesis that the more rapid an organism's development, the greater the effect of infantile experience. In addition to incorporating our data as well as the findings of Levine and Otis and Levine and Cohen, this hypothesis also accounts for the findings of King and Eleftheriou (*7*), who studied the effects of infantile stimulation upon two subspecies of the deer mouse, *Peromyscus maniculatus.* They found that *P. maniculatus bairdii,* a rapidly maturing organism, was deleteriously affected by the infantile stimulation, while *P. maniculatus gracilis,* a slowly maturing organism, was facilitated by the identical stimulation, as measured by behavioral tests of activity and learning, and by adrenal weights. Since a more rapidly maturing organism may have a shorter infantile period, the use of developmental indices such as eye opening may be a more appropriate basis for the administration of stimulation than the use of absolute age.

The mechanisms underlying these phenomena are as yet unknown. However, it is apparent that body weight is not related to survival time in any simple manner. It is also apparent that there is more similarity between the weight data for the rat and mouse than between the survival results. Denenberg has suggested (*4*) that the effect of infantile handling is to stress the organism, and this stress acts to reduce the animal's responsiveness to later stressing agents. The greater the magnitude or duration of the infantile stress, the greater is the reduction in responsiveness. The initial effect of reducing responsiveness to stress is to bring about a facilitation in performance (for example, through reducing emotionality), while prolongation of the infantile experience results in an organism which exhibits impaired performance. Within each species the present results are consistent with this hypothesis, but it is apparent that the age during which the organism is stimulated is another critical parameter. When making comparison across species, developmental rates, and probably other parameters, must be considered.

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15 July 1959

Procedure for Studying Olfactory Discrimination in Pigeons

Abstract. A discrimination, based on olfactory stimuli, was established in two pigeons by an operant conditioning procedure. Results from control sessions demonstrate that the discrimination can be attributed only to the presence or absence of olfactory stimuli.

Experiments designed to determine whether birds possess a sense of smell have had equivocal results. Some workers have reported that birds are able to make precise olfactory discriminations, while others have found that birds fail completely in discriminating the presence of olfactory stimuli (*1*). Procedural difficulties and artifacts have marred the many experimental procedures that have been used by these workers. An experi-

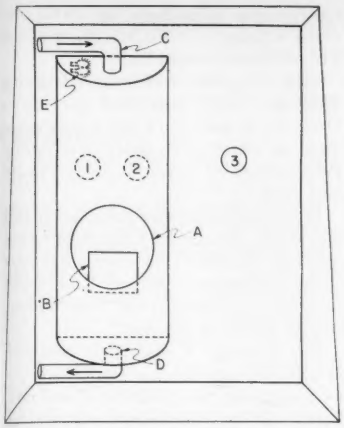

Fig. 1. View of front wall of the experimental chamber. All structures shown with broken lines are inside the cylinder. (See text.)

ment in which a standard training procedure is adapted for establishing discriminations based on olfactory stimuli (2) is described in this report.

The experimental chamber is a modified picnic icebox (3). Mounted on the left side of the front wall (see Fig. 1) is an aluminum cylinder with a circular opening *A*, which gives the bird access to two Plexiglas discs, Nos. 1 and 2 in the figure. These discs, here referred to as keys, are transilluminated by two 6-watt lamps, (key No. 1, with blue; key No. 2, with red) mounted behind the front wall. An opening *B* to a grain feeder is below these keys. A copper fitting *C* is mounted on the roof of the cylinder and is connected to a network of glass tubing through which a controlled stream of air can be passed. The apparatus used to deliver the olfactory stimulus is similar in type to that reported by Pfaffmann *et al.* (4), except that electric valves are used instead of stopcocks. A second copper fitting *D* is mounted on the floor of the cylinder and is connected to an exhaust pump that operates continuously during each experimental session. Two 6-watt lamps, *E*, illuminate the inside of the cylinder. A third key, No. 3, is mounted on the front wall outside the cylinder and is transilluminated by a yellow light. A 15-watt white lamp illuminates the chamber outside the cylinder. Four exhaust blowers are mounted on the walls of the chamber. The chamber and cylinder floors are covered with activated charcoal to trap lingering odors. A "white" masking noise is present throughout all sessions.

A trial begins with the illumination of both key No. 3 and the 15-watt lamp. A response (a peck) on this key initiates the flow of air into the cylinder through *C*. Nine seconds after this first peck, another peck turns off all the lights outside the cylinder and causes the interior of the cylinder to be illuminated. If the air stream is carrying an odor, the bird is rewarded with food for pecking seven times on key No. 1. Four pecks on key No. 2—that is, four incorrect responses—terminates the trial, and the pigeon receives no reward. If the air stream does not contain an odor, seven pecks on key No. 2 reward the animal with food, whereas four pecks on key No. 1 end the trial, without reward.

The odor and no-odor conditions are presented randomly from trial to trial, except that a correction procedure is always followed. When a trial terminates because the pigeon has made four pecks on the incorrect key, the same stimulus conditions are presented again during the next trial. The conditions may change only after seven pecks on the correct key have occurred in one trial. This procedure for changing the stimulus conditions prevents perseverative responding, which would otherwise reward responding on a single key 50 percent of the time.

Two male white Carneaux pigeons, maintained at 80 percent of their free-feeding body weights, undergo 50 trials in each session. Every trial, whether it ends in food reward or not, is followed by a 1-minute period when all lights are out. During this time, all exhaust fans operate and the odor-delivery system is cleaned.

Figure 2 shows the mean number of correct trials out of 50 for birds Nos. 264 and 263 under different conditions. Bar A shows the results for seven sessions in which sec-butyl acetate and distilled water were used as the odor and no-odor stimuli. The former has a strong odor and is also a trigeminal nerve irritant; it was used to maximize the likelihood that a discrimination would be established. After the discrimination had been established, a different odorant was used—isooctane, a substance with minimal irritating effects (5). Bar B shows the mean number of correct trials for 11 sessions in which isooctane was used as the stimulus.

Since there remains a possibility that some peculiarity of the delivery system, such as a difference in noise or pressure between the odor and the no-odor conditions, acted as a stimulus, a control session was set up for each bird. In the control session for bird No. 264, both the saturators in the delivery system were filled with distilled water. When air passed through the saturator that formerly contained isooctane, seven pecks by bird No. 264 on key No. 2 produced the food reward. For bird No. 263, both saturators were filled with isooctane. When air passed through the saturator that formerly contained distilled water, seven pecks on key No. 1 produced the food reward. No other procedural changes were made.

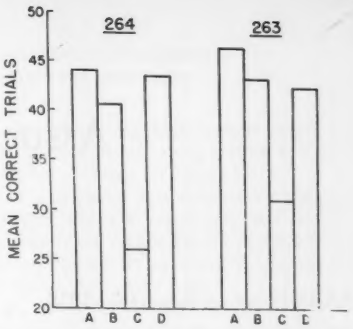

Fig. 2. Mean number of correct trials out of 50 trials for birds Nos. 264 and 263 under different experimental conditions. Bar A, trials with sec-butyl acetate (mean of seven sessions); bar B, trials with isooctane (mean of 11 sessions); bar C, control session; bar D, post-control sessions (mean of 32 sessions).

If the discrimination established with isooctane as the odorant was due to some artifact in the procedure, these changes would not have altered the number of correct trials during the control as opposed to previous experimental sessions.

The results of the control session (bar C) demonstrates that this is not the case. The fact that the performance drops far below the level maintained under the original conditions is evidence that pigeons can respond differentially to the presence or absence of an odorous substance. Following the control session, further trials were run with isooctane, under the conditions described above. Bar D, based on 32 sessions, shows that the mean number of correct trials returned to approximately the precontrol level for both birds.

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5 May 1959

Association Affairs

AAAS Finances: Report for 1958

The 1958 income of the American Association for the Advancement of Science for normal and continuing operating expenses amounted to $992,504.03. This amount was divided as follows:

Annual dues paid by members	$422,080.96
Money transferred from Investment Account to pay for subscriptions for emeritus and life members	6,036.00
Subscriptions to *Science* by nonmembers	69,878.10
Sales of single copies and back issues	4,584.40
Advertising in *Science*	328,637.60
Sales of symposium volumes	30,637.00
Annual meeting: registration fees, exposition space, advertising in program, and contributions	42,257.92
Income from investment of funds not needed in checking account	14,365.18
Rental income from third floor and garage	20,213.68
Allowance for expenses incurred in administering grants	44,562.16
Miscellaneous receipts	9,251.03
Total	$992,504.03

These receipts amounted to $37,376.79 more than the operating expenses. The chief items of expense were:

Printing and editing *Science*	$551,747.50
Cost of selling advertising in *Science*	82,194.66
Printing and editing symposium volumes	8,445.09
Expenses of the annual meeting	43,861.31
Allowances ($1 per member) to Pacific, Southwestern and Rocky Mountain, and Alaska divisions	8,787,00
Expenses of AAAS sections	4,607.85
Board of Directors' meetings	5,133.52
Meetings of committees	4,065.34
Administrative and general expense	45,416.62
Business office, salaries, and other expenses	98,724.30
Circularization of new members (exclusive of salaries)	12,279.78
Building maintenance	36,643.85
Real estate taxes	12,908.52
Depreciation allowance on building	23,519.16
Depreciation allowance on equipment	7,220.91
Miscellaneous other expenses	9,571.83
Total	$955,127.24

In addition to the excess of income over expense of $37,376.79, endowment funds increased by $20,406.43, and the Association set aside, as is shown in the figures given above, $30,740.07 for depreciation of building and equipment.

Comparison of 1958 with 1957

Receipts in 1958 were $156,787.90 greater than in 1957. The two major differences were an increase of approximately $90,000 in annual dues—attributable primarily to the fact that dues were increased at the beginning of 1958 from $6.50 a year to $8.50 a year—and an increase of approximately $64,000 in advertising revenue.

Expenses for 1958 exceeded those of 1957 by $130,719.21. The largest difference was the greater cost of distributing *Science* to all Association members in 1958 over the cost in 1957 of sending *Science* to some members and *The Scientific Monthly* to others.

Grants Administered during 1958

Funds from grants received during 1958 or held over from earlier years amounted to $662,409.80. Grant funds expended during the year amounted to $572,658.38, leaving an unexpended balance to carry over into 1959 of $89,751.42.

The largest amount was for the Traveling High School Science Libraries administered by the AAAS and supported by funds from the National Science Foundation. The amount available during the year was $443,925.60, and the amount expended, $433,053.09, leaving an unexpended balance of $10,872.51.

The next largest grant was from the Carnegie Corporation for the Science Teaching Improvement Program. During 1958 the Association received the first third of a second three-year grant to support this program. The initial grant was for $300,000, received in equal amounts in 1955, 1956, and 1957. In 1958 the Carnegie Corporation made an additional grant of $250,000 to continue this program. Of this amount, $83,334 was received in 1958. That amount, plus carry-over from 1957, provided a budget of $155,340.50, of which $72,466.50 was expended.

Smaller grants were received during 1958, or money was held over from 1957, for a variety of other programs, some of which were completed during 1958, others of which have continued into 1959.

From the Rockefeller Foundation and the Sloan Foundation, the Association received $17,856.91 to cover the costs of the Parliament of Science held by the Association in March 1958. This amount exactly balanced the cost.

The Carnegie Corporation provided $12,000 for simultaneous conferences on the testing and the guidance of students. Reports of the conferences consisted of recommendations for the establishment of testing and guidance programs in schools, and were prepared in anticipation of the enactment of the National Defense Education Act of 1958. Of this grant, the Association held a balance at the end of the year of $788.80. This amount was returned to the Carnegie Corporation in 1959.

The Rockefeller Foundation provided $9000 for a study of the attitudes of students toward scientists and careers in science. The study, being conducted by Margaret Mead and Rhoda Metraux, held a balance at the end of the year of $6916.02.

The Ford Foundation and other sources provided $8822.67, the exact cost of a series of meetings of a panel that prepared a report on the role of the behavioral sciences, "National Support for Behavioral Science."

From the National Science Foundation the Association received a grant of $4000 to pay the expenses of lecturers appearing on the lecture series jointly sponsored by the Association and the NSF. At the end of the year the balance was $2932.69.

The Association received, during 1958, $1200 as the first two contributions toward the expenses of the First International Oceanographic Congress, which has just been held in New York from 30 August through 11 September under the joint auspices of UNESCO, the Special Committee on Oceanic Research of the International Council of Scientific Unions, and the AAAS.

At the beginning of 1958 there remained a balance of $2880.86 of a grant from the General Electric Educational and Charitable Fund to provide for the expenses of regional consultants working under the Science Teaching Improvement Program. The whole amount was spent during the year.

At the beginning of 1958 the Association held a balance of $2668.49 from a grant from the Ford Foundation to help pay the expenses of a study of pro-

Kodak reports on:

why the radiologists, cardiologists, urologists, internists, laryngologists, and neurosurgeons got together . . . a biochemical reagent and metabolic inhibitor that transforms *Salmonella* . . . a method for forecasting titanic stress in fine detail . . .

Cinefluorography

On the other side of town, on November 14 and 15 of last year, there was held the First Annual Symposium on Cinefluorography of the University of Rochester School of Medicine and Dentistry.

To the masses, many of whom may live longer or at least enjoy themselves more than if this conclave had never convened, it would have been mildly interesting to know that x-ray movies of the innards in action had so far advanced from a stunt (for TV science programs) to a diagnostic routine as to make it a subject for a convention. Very mildly interesting, on a November Saturday which already offered the intellectual challenge of picking point spreads for the football games.

To the 150-odd ambitious, clear-eyed radiologists, cardiologists, urologists, internists, laryngologists, and neurosurgeons who came from all over, it was far, far more than a chance to flee the daily hurly-burly for an unequivocally tax-deductible weekend. At this time and place began the process of shaping into standard working technique all the individual improvisations, frustrations, and foolish pioneer feelings experienced late at night in deserted laboratories by medical men coping with electronics, optics, photographic sensitometry, and random fluctuations at the quantum level.

To certain elements of the electronics industry the symposium brought visions of a well-bred market for advanced merchandise, quite free of the fearful dependence on military spending and of the fearful perils of appliance merchandising. If the electronics boys in 1953 hadn't brought out image amplifiers that multiply fluoroscope image intensity a thousandfold or more so that film can be exposed without frying patients, there would have been no symposium. Their emissaries sat unabashed among the M.D.'s.

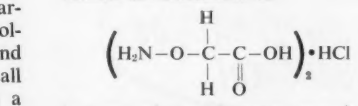
To the University of Rochester it was a chance to become the national cinefluorographic capital. It had become involved with the subject as early as 1929. To have one member of its radiology department such an expert on motion picture quality that he had produced Poe's "The Fall of the House of Usher" to supra-professional cinematic standards had helped enormously. We helped, too.

To us, doomed by our charter to the endless pursuit of monetary gain, the symposium was important for stimulating sales of *Kodak Cineflure Film*, a product which uniquely combines extreme speed to green light with very high contrast. It is obtainable from most x-ray dealers.

To Charles C Thomas, Publisher, Springfield, Ill., the symposium provided a title he is publishing this month, Cinefluorography. *It contains all 19 papers and the discussion thereof. For a free copy of a bibliography of cinefluorography, write Eastman Kodak Company, Medical Division, Rochester 4, N. Y.*

A deft way with ketones

(Aminooxy)acetic Acid Hemihydrochloride, known in the biochemical literature as carboxymethoxylamine hemihydrochloride and with less chance for confusion as



is now going to become even better known as Eastman 5336.

Now that the great virtue of easy availability has been bestowed on this compound, it commands interest on several grounds:*

1) The still mysterious transformation of bacilli and colonies of bacilli into the so-called L form—a bacteriological phenomenon being closely watched—has been shown to be induced in *Salmonella typhosa* by this acid in a narrow concentration range *(J. Bact., 59,775).*

2) Its ability to combine in living organisms with α-ketones, principally pyruvate, makes it a metabolic inhibitor useful as a bacteriostatic agent in preparations of high protein content, such as blood-typing serums and bacterial vaccines *(J. Bact., 55,1).*

3) It is useful as a reagent for the isolation of very small amounts of ketones from unsaponifiables such as cholesterol and its metabolic products *(J. Biol. Chem., 114,539).*

4) It is useful for isolation of α-estradiol from human pregnancy urine *(J. Biol. Chem., 134,591).*

Abstracts of the latter two analytical procedures with Eastman 5336, or List No. 41 of some 3700 other Eastman Organic Chemicals, will be furnished upon application to Eastman Organic Chemicals Department, Distillation Products Industries, Rochester 3, N.Y. (Division of Eastman Kodak Company). The compound itself may be ordered at $3.55 for 5 grams.

Photoelasticity by the slice

Westinghouse, long known as a hotbed of photoelastic activity, has been nice enough to cast upon the waters of industrial co-prosperity a piece of technique that could help sell more *Kodak Contour Projectors.* No time must be lost in spreading the word.

Westinghouse took one of these projectors of ours and turned it into a magnifying polariscope. This they did in the interest of reaching reasonable decisions on the mechanical design details to enable a nuclear reactor pressure vessel to withstand the titanic stresses that it must bear.

Scale models were built out of a certain transparent epoxy resin which not only exhibits the well known differential retardation between light polarized parallel and perpendicular to the stresses, but can retain the effect "frozen in" after the pressure is released and the model is literally sliced up in various planes of interest to the stress analysts. The *Kodak Contour Projector* is what brings the analyst in close, past the gross structure of the pattern, to the all-important fine details where structural failure starts.

Don't bother Westinghouse for a description of the optical, mechanical, and electrical additions they've made to the projector. It's enough that they are publishing a full description of the analytical method (Proceedings of the Society for Experimental Stress Analysis, *17,* No. 1). *They're not interested in selling projectors. Eastman Kodak Company, Special Products Division, Rochester 4, N. Y., is.*

Price quoted is subject to change without notice.

Kodak
TRADE MARK

'Tis a speculation whether progress in these matters was advanced or retarded by Hans Thacher Clarke's leaving us 32 years ago to build Columbia University's great Department of Biological Chemistry. (Aminooxy)acetic acid was first synthesized in Germany in 1893. It is astounding what a large proportion of all organic chemicals later found interesting for one reason or another were first synthesized in Germany in 1893. Apparently this one, like so many others, just lay there in the literature until Professor Clarke suggested it for reaction with carbonyl compounds. Shortly after the suggestion proved fruitful, he and a collaborator came out with an improved synthesis of the compound. At this point, had he still been heading up the production of Eastman Organic Chemicals, he would doubtless have added it to our list, making it conveniently available to all way back in 1936 and thus advancing progress. But if he hadn't quit to be a college professor, he'd be tied up in a lot of dull business routine. This would have retarded progress because he wouldn't have been sitting around with graduate students and research scholars tossing out brilliant suggestions that are still gaining momentum a quarter century later. Anyway, the synthesis we use for Eastman 5336 now is not identical with Dr. Clarke's. A Texan who tried his synthesis reported she wound up with merely ammonium chloride unless she was very careful.

This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

posed changes in the Internal Revenue Code designed to increase private and corporate gifts to institutions of higher education. The whole amount was spent during the year.

During 1958 the Association entered into an agreement with the National Science Foundation to administer a program of fellowships for one, two, or three summers for high-school teachers of science and mathematics who were deemed qualified for individually arranged programs of study to increase their competence in the subject fields. The contract with the National Science Foundation was negotiated during 1958, but no funds were received during that year. Expenses in 1958 amounted to $11,453.45. These expenses were covered by funds received from NSF during 1959.

Investment Account

The Association maintains a separate investment account in which endowment and investment funds are segregated from current funds and from grants for special activities. During 1958 the Association transferred to the investment account $190,604.14 of current funds. The transfer was made in order to earn a higher rate of interest on funds not immediately needed for operating expenses. Records of the total amount of money and of earnings are maintained in such a fashion as to permit return to the operating account at any time of whatever amount of this money may be needed. For investment purposes, however, the amount is merged with the Association's endowment funds. Consequently, in the figures given in the following table it is impossible to show how much of the several kinds of securities should be credited to endowment funds and how much to current operational funds. The combined account was distributed as follows at the end of 1958:

U.S. Government bonds	$164,196.87
Industrial bonds	197,387.60
Preferred stocks	58,908.59
Common stocks	283,986.84
Total	$704,479.90

Of the above total, $190,604.14 consists of operating funds and $513,875.76 of endowment funds. The latter figure is $19,300.83 above the total for the endowment fund at the end of 1957. All of these figures are at cost or book value rather than at the market value of the securities held. During the year the Association received $23,545.51 in dividends and interest. The return was at the rate of 3.8 percent on the amount of money invested. (Neither the book nor the market value, but the actual amount of money that at various times had been put into the investment account, was used to calculate the rate.) The yield on the market value was 3.4 percent. The income was used as follows:

Investment counsel and cost of servicing securities	$ 2,345.44
Grants to affiliated academies of science	4,324.50
Transferred to operating funds for life and emeritus members	6,036.00
To the Gordon Research Conferences	1,877.73
Award and expenses of Newcomb Cleveland Prize	1,350.00
Expenses of Socio-Psychological Prize	350.00
Increase in value of endowment funds	7,261.84
Total	$23,545.51

During the year the Association also gained $8992.47 from the sale of securities.

Consolidated Balance Sheet

At the end of 1958, the consolidated balance sheet of the Association, which includes both operating and investment funds, showed the following assets:

Cash on deposit	$ 167,292.92
Investments at cost	
Operating account	704,479.90
Investment account	223,049.52
Land	115,875.00

Building (less depreciation)	723,214.03
Equipment (less depreciation)	67,884.53
Money owed to the Association	69,651.55
Total	$2,071,447.45

These assets were partially offset by the following liabilities:

Prepaid dues and subscriptions for which members and other subscribers had not received *Science* or other services	$370,601.39
Unexpended balance of grants from National Science Foundation, Carnegie Corporation, and Rockefeller Foundation	89,751.42
Accounts payable to others	98,993.57
Remainder of mortgage on building payable in 7½ years	137,788.46
Held for Gordon Research Conferences	39,083.28
Total	$736,218.12

The difference between assets and liabilities represents the Association's net worth. At the end of 1958, the net worth was distributed as follows:

Endowment funds:	
For research	$ 205,547.28
For general purposes (used to pay subscription costs for life and emeritus members)	206,213.57
For the Newcomb Cleveland Prize	27,210.00
For the Socio-Psychological Prize	29,901.60
For creating emeritus life memberships	3,751.83
Value of land	115,875.00
Value of building and equipment (less depreciation and mortgage)	653,310.10
Unallocated reserve	93,419.95
Total	$1,335,229.33

Auditor's Report

The Association's financial records for 1958 were audited, as they have been for a number of years, by the firm of G. P. Graham and Company. The tables presented above differ in form from those included in the auditor's report, and the explanations of sources of income and nature of expense are usually given in greater detail. In a few instances items have been reclassified from the auditor's report to provide more meaningful groupings. Except for such rearrangements, there are no differences between the figures presented here and those reported in the audited account, to which was attached a letter ending: "In our opinion the accompanying statements present fairly the financial position of the American Association for the Advancement of Science as at December 31, 1958, and the results of its operations for the year ended on that date, and were

prepared in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year. Respectfully submitted, G. P. Graham and Company, by G. R. Bowers."

DAEL WOLFLE
American Association for the Advancement of Science

Forthcoming Events

October

1–4. American Soc. of Industrial Designers, Asheville, N.C. (Mrs. R. R. Larisch, ASID, 15 E. 48 St., New York 17.)

4–7. American Inst. of Mining, Metallurgical and Petroleum Engineers, fall, Dallas, Tex. (E. O. Kirkendall, AIMMPE, 29 W. 39 St., New York 18.)

4–9. Society of Motion Picture and Television Engineers, semi-annual conv., New York, N.Y. (C. S. Stodter, SMPTE, 55 W. 42 St., New York, 36.)

5–7. Aeronautical Communications, 5th symp., Utica, N.Y. (L. G. Cumming, Inst. of Radio Engineers, 1 E. 79 St., New York 21.)

5–7. Association of Medical Illustrators, 14th annual, Seattle, Wash. (J. W. Phillips, Univ. of Washington College of Medicine, Seattle.)

5–7. Chemical Engineers, annual, Essen, Germany. (Dr. Miessner, VDI-Fachgruppe, Verfahrenstechnik, Rheingaualiee 25, Frankfurt-am-Main.

5–7. National Assoc. of Corrosion Engineers, Northeast regional, Baltimore, Md. (T. J. Hull, NACE, 1061 M & M Bldg., Houston, Tex.)

5–8. American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

5–9. American Soc. of Anesthesiologists, Bal Harbour, Fla. (J. W. Andes, 188 W. Randolph St., Room 1101, Chicago, Ill.)

5–9. Audio Engineering Soc., 11th annual, New York, N.Y. (AES, P.O. Box 12, Old Chelsea Station, New York 11.)

5–10. Society of Automotive Engineers, aeronautical meeting and aircraft manufacturing forum, Los Angeles, Calif. (R. W. Crory, Meetings Operation Dept., SAE, 485 Lexington Ave., New York 17.)

5–16. Institute of the Aeronautical Sciences, biennial Anglo-American conf., New York, N.Y. (R. R. Dexter, IAS, 2 E. 64 St., New York 21.)

6. American Assoc. of Poison Control Centers, 2nd annual, Chicago, Ill. (A. S. Blank. AAPCC. Connecticut State Dept. of Health, Hartford 15.)

6–8. Aeronautical/Astronautical Problems of High Speed Flight, Stanford, Calif. (E. Haynes, Deputy Director, Aero Sciences Directorate, Air Force Office of Scientific Research, Washington 25.)

6–9. High Temperature Technology, intern. symp., Asilomar, Calif. (Public Relations Office, Stanford Research Inst., Menlo Park, Calif.)

7–8. Advanced Propulsion, 2nd symp. (classified), Boston, Mass. (Lt. Col. P. Atkinson, Propulsion Div., Air Force Office of Scientific Research, Washington 25.)

7–9. Vacuum Technology, symp., Philadelphia, Pa. (American Vacuum Soc., Box 1282, Boston, Mass.)

7–11. International Conv. on Nutrition and Vital Substances, 5th, Konstanz-Zurich, Switzerland. (Secretary General, Benmeroderstrasse 61, Hannover-Kirchrode, Germany.)

8–10. American Assoc. of Textile Chemists and Colorists, natl. conv., Washington, D.C. (G. P. Paine, AATCC, P.O. Box 28, Lowell, Mass.)

8–10. American Ceramic Soc., Bedford, Pa. (F. P. Reid, ACS, 4055 N. High St., Columbus 14, Ohio.)

8–10. American Soc. of Tool Engineers, semi-annual, St. Louis, Mo. (H. E. Conrad, ASTE, 10700 Puritan Ave., Detroit 38, Mich.)

8–10. Biology of Pyelonephritis, intern. symp., Detroit, Mich. (E. L. Quinn, Henry Ford Hospital, W. Grand Blvd. at Hamilton, Detroit 2.)

8–10. Optical Soc. of America, annual, Ottawa, Canada. (S. S. Ballard, Dept. of Physics, Univ. of Florida, Gainesville.)

9–13. American Soc. of Civil Engineers, Los Angeles, Calif. (E. S. Kirkpatrick, ASCE, 33 W. 39 St., New York 18.)

11–16. American Acad. of Ophthalmology and Otolaryngology, Chicago, Ill. (W. L. Benedict, 15 Second St., SW, Rochester, Minn.)

11–16. American Inst. of Electrical Engineers, fall general, Chicago, Ill. (N. S. Hibshman, AIEA, 33 W. 39 St., New York 18.)

11–16. American Soc. for Testing Materials, Pacific area natl., San Francisco, Calif. (R. J. Painter, ASTM, 1916 Race St., Philadelphia 3, Pa.)

12–14. Clay Conf., 8th natl., Norman, Okla. (C. G. Dodd, Eighth Natl. Clay Conf., Univ. of Oklahoma, Norman.)

12–14. Electronics Conf., 15th annual natl., Chicago, Ill. (NEC, 228 N. La Salle St., Chicago 1, Ill.)

12–16. Macromolecules, intern. symp. (IUPAP), Wiesbaden, Germany. (W. Mauss, Intern. Symp. on Macromolecules, c/o Kalle & Co., Rheingaustrasse 25, Wiesbaden-Biebrich, Germany.)

12–19. Venereal Diseases, intern. cong. (by invitation), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1, England.)

13–17. International Union against the Venereal Diseases and the Treponematoses, London, England. (Institut Alfred Fournier, 25, Boulevard Saint-Jacques, Paris 14e, France.)

14–16. Parenteral Drug Assoc., annual conv., New York, N.Y. (H. E. Boyden, Parenteral Drug Assoc., 130 E. 59 St., New York 22.)

14–17. American College of Chest Physicians, 25th, Albuquerque, N.M. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

15–16. American Ceramic Soc., Glass Div., Wernersville, Pa. (F. P. Reid, ACS, 4055 N. High St., Columbus 14, Ohio.)

15–17. Academy of Psychosomatic Medicine, Cleveland, Ohio. (B. B. Moss, Suite 1035, 55 E. Washington St., Chicago 2, Ill.)

15–17. National Soc. of Professional Engineers, fall meeting, Seattle, Wash.

(P. H. Robbins, NSPE, 309 Bancroft Bldg., Univ. of Nebraska, Lincoln.)

16–17. Association of Midwest College Biology Teachers, conf., Notre Dame, Ind. (G. R. Bernard, Dept. of Biology, Univ. of Notre Dame, Notre Dame, Ind.)

17–18. American Acad. of Psychotherapists, 4th annual conf., New York, N.Y. (AAP, 30 Fifth Ave., New York 11.)

17–25. Plastics Industry, intern. fair, Düsseldorf, Germany. (Nordwestdeutsche Ausstellungs Gesellschaft (NOWEA), Ehrenhof 4, Düsseldorf.)

18–22. Electrochemical Soc., Columbus, Ohio. (R. K. Shannon, ES Inc., 216 W. 102 St., New York 25.)

18–23. American School Health Assoc., Atlantic City, N.J. (A. O. DeWeese, 515 E. Main St., Kent, Ohio.)

18–23. American Soc. of Plastic and Reconstructive Surgery, Miami Beach, Fla. (T. R. Broadbent, 508 E. South Temple, Salt Lake City, Utah.)

19–21. High Polymer, 9th Canadian, Toronto, Ontario, Canada. (K. E. Russell, Dept. of Chemistry, Queen's Univ., Kingston, Ontario.)

19–22. Semiconductor Symp. (Electrochemical Soc.), Columbus, Ohio. (A. C. Beer, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.)

19–23. American Public Health Assoc., 87th annual, Atlantic City, N.J. (B. F. Mattison, 1790 Broadway, New York 19.)

19–23. American Soc. of Civil Engineers, annual conv., Washington, D.C. (W. H. Wisley, ASCE, 33 W. 39 St., New York 18.)

19–23. Radioisotopes in the Biosphere, symp., Minneapolis, Minn. (R. B. Caldecott, Center for Continuation Study, Univ. of Minnesota, Minneapolis 14.)

19–31. International Cong. of Therapeutics, Strasbourg, France. (Prof. Fontaine, Dayen de la Faulte de Strasbourg, France.)

19–31. Pan American Medical Assoc., 10th conf., Mexico, D.F., Mexico. (J. Eller, PAMCA, 745 Fifth Ave., New York 22.)

20–21. Reprocessing of Nuclear Fuels, AEC symp., Richland, Wash. (J. T. Christy, Hanford Operations Office, U.S. Atomic Energy Commission, Richland, Wash.)

20–22. Standards, 10th natl. conf., Detroit, Mich. (K. G. Ellsworth, American Standards Assoc., 70 E. 45 St., New York 17.)

20–23. Clean Air, intern. conf., London, England. (National Soc. for Clean Air, Palace Chambers, Bridge St. London, S.W.1, England.)

22–24. Acoustical Soc. of America, fall meeting, Cleveland, Ohio. (W. Waterfall, ASA, 335 E. 45 St., New York 17.)

22–24. American Documentation Inst., annual, Bethlehem, Pa. (C. G. LaHood, Jr., Library of Congress, Washington 25.)

22–25. British Medical Assoc., annual clinical, Norwich, England. (W. Hedgcock, BMA House, Tavistock Sq., London, W.C.1, England.)

23–24. Canadian Soc. for the Study of Fertility, Montreal, Canada. (J. F. Campbell, 238 Queen's Ave., London, Ont., Canada.)

23–25. American College of Cardiology, 8th annual, Philadelphia, Pa. (P. Reichert, ACC, Empire State Bldg., New York 1.)

23–27. American Heart Assoc., annual, Philadelphia, Pa. (W. F. McGlone, AHA, 44 E. 23 St., New York 10.)

24–29. Darwin Centennial, intern. celebration, Chicago, Ill. (Office of Public Relations, Univ. of Chicago, Ill.)

24–29. First All-India Cong. of Zoology, Jabalpur. (B. S. Chauhan, Zoological Survey of India, 34 Chittaranjan Ave., Calcutta 12.)

26–27. American Cancer Soc., New York, N.Y. (ACS, 521 W. 57 St., New York 19.)

26–27. Griseofulvin and Dermatomycoses, intern. symp., Miami, Fla. (H. Blank, Dept. of Dermatology, Univ. of Miami School of Medicine, Miami 36.)

26–28. Aeronautical and Navigation Electronics, IRE conf., Baltimore, Md. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

26–28. Analytical Chemistry in Nuclear Reactor Technology, 3rd conf., Gatlinburg, Tenn. (C. D. Susano, Oak Ridge Natl. Lab., Box Y, Oak Ridge, Tenn.)

26–28. Gas Lubricated Bearings, 1st intern. symp., Washington, D.C. (S. W. Doroff, Power Branch, Office of Naval Research, Washington 25.)

(See issue of 21 August for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable, and it reflects the claims of the manufacturer or other source. Neither Science *nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed appears on page 646.*

■ CLOSED-CIRCUIT TELEVISION CAMERA is designed to be inserted into tubes 3 in. or more in diameter for inspection of inside surfaces. The television monitor and the camera-control-power unit, which complete the closed circuit system, are mounted on a cart. (Diamond Power Specialty Corp., Dept. 37)

■ INFRARED ABSORPTION CELL consists of a single block of rock salt in which a cavity has been produced by ultrasonic machining. Faces of the cell are cleaved. Thicknesses range from 0.1 to 5 mm. The cavities are filled and cleaned by hypodermic syringe and are stoppered with polyethylene. Adapters are available for use with any commercial infrared spectrometer. (Connecticut Instrument Corp., Dept. 38)

■ SPECTROPHOTOMETER ACCESSORIES for the manufacturer's ultraviolet-visible-near-infrared spectrophotometer include a specular-reflectance attachment and a diffuse-reflectance-sphere attachment. The specular-reflectance attachment, suitable for measuring flat surfaces, provides a sample beam that strikes the sample at incident angle of 20 deg. The diffuse-reflectance sphere permits measurements of solid samples as well as liquid or solid scattering samples. Beam size at the sample is 25 by 32 mm. The specular component can be retained or rejected. (Perkin-Elmer Corp., Dept. 39)

■ TELEMETERING SIGNAL GENERATOR has radio-frequency of range 195 to 270 Mcy/sec. Three frequency-deviation ranges, 0 to 24, 0 to 80, and 0 to 240 kcy/sec, are each continuously adjustable. Internal amplitude modulation from 0 to 50 percent is available. Overall FM distortion at 75 kcy/sec is less than 2 percent; at 240 kcy/sec it is less than 1 percent. Maximum open-circuit output voltage is 0.4 v. Accuracy is ± 0.5 percent after warm-up. (Boonton Radio Corp., Dept. 42)

■ TAPE PERFORATOR has punching speed of 40 columns per second. As the drive shaft of the device completes half of the revolution required to punch each column, the perforator will accept the signal from the next column. Tape up to 1-in. wide is accepted with code column up to eight channels. Models with up to 30 channels are available on special order. (Telecomputing Corp., Dept. 44)

■ SEQUENCE TIMER, operated by battery, is reported to have a very low power requirement. The unit is of cam-operated microswitch type. It is driven by a motor with speed regulation accurate within ± 1 percent for voltage drops up to 50 percent. Switch capacity may be 5 or 20 amp. (Brailsford & Co., Dept. 41)

■ PRESSURE-RATIO COMPUTER measures compressor inlet and outlet pressures, indicates pressure ratio on an integral scale, and generates a pneumatic signal proportional to the ratio. Pressure elements are available for use over a continuous range from 0 absolute to 500 lb/in.² gage. Ratios of 1 to 5 can be measured throughout a pressure-turndown range of 20 to 1. (Hagan Chemicals & Controls, Inc., Dept. 45)

■ METERING PUMP features volume-per-stroke adjustability while running. Pump bodies are made of ceramic, tempered glass, or Teflon. Plungers are ceramic. Stroke rate is 95 per minute; stroke length is adjustable from 0 to 19/32 in. The pump will operate against back pressure of 28.5 lb/in². (C. H. Stoelting Co., Dept. 49)

■ ULTRASONIC FLAW DETECTOR is a portable instrument offering choice of any frequency of operation between 0.4 and 10 Mcy/sec, depending on the transducer selected. Adjustment to any frequency within the range is automatic. An optional flaw alarm signals that test limits have been exceeded. (Branson Instruments, Inc., Dept. 50)

■ CLOSED-CIRCUIT TELEVISION SYSTEM provides 1000-line horizontal resolution and 700-line vertical resolution. Bandwidth for the complete system is 20 Mcy/sec. The system is available with preset line rates of 675, 875, or 1035 lines per frame at 60 fields, 30 frames per second. Aspect ratio is variable between 1:1 and 3:4 (height to width). Variations of line voltage ± 10 percent of nominal 117 v do not cause picture deterioration. (General Precision Laboratories, Inc., Dept. 51)

■ IMPEDANCE BRIDGE measures inductance and Q of inductors, capacitance and dissipation factor of capacitors, and a-c and d-c resistance. Resistance range is 1 milliohm to 10 megohm; capacitance 1 pf to 1000 μf; inductance 1 μh to 1000 h. Dissipation factor D of capacitors is measured from 0.001 to 50 at 1 kcy/sec. Q of inductors is measured from 0.02 to 1000 at 1 kcy/sec. Accuracies of ± 1 percent for R, C, and L and ± 5 percent for Q and D are claimed. (General Radio Co., Dept. 54)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of box number counts as 10 additional words. Payment in advance is required. **Positions Open,** $33 per inch or fraction thereof. No charge for box number.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for box number. Monthly invoices will be sent on a charge account basis — provided that satisfactory credit is established.

Single insertion	**$33.00 per inch**
4 times in 1 year	**30.00 per inch**
7 times in 1 year	**28.00 per inch**
13 times in 1 year	**27.00 per inch**
26 times in 1 year	**26.00 per inch**
52 times in 1 year	**25.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

Neuroanatomist-Neurophysiologist, Ph.D. Zoology and medical school teaching; Phi Kappa Psi, Alpha Kappa Kappa, Sigma Xi. Age 33; 14 publications. Curriculum vitae. Write Box 200, SCIENCE. 8/28; 9/4, 11, 18, 25

(a) **Ph.D., Physiology;** experience in burn shock and aviation, physiology research, and science information. (b) **Ph.D., Chemistry;** teaching and research experience in protein chemistry, metabolism, and enzymes. Medical Bureau, 900 North Michigan, Chicago. X

Virologist, Ph.D. For research, teaching, in virologist, tissue culture. Experience in medical microbiology, phage transduction. Box 212, SCIENCE. 9/11, 18, 25

POSITIONS OPEN

BACTERIOLOGISTS
Research

Challenging positions are open for bacteriologists with a bachelor's degree and 2 to 4 years' research experience, preferably in public health or microbiology. These positions offer opportunity to use your initiative and creative ability on interesting and varied programs. Excellent employee benefits and liberal vacation policy. Please send résumé to:

E. P. Bloch
ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35 Street
Chicago 16, Illinois

(a) **Clinical Microbiologist;** M.D., Ph.D., to supervise bacteriology, responsible developmental work in microbiology, research; large diagnostic clinic, affiliated 500-bed general hospital, fully approved; prominent mideastern university city. (b) **Biochemist;** Ph.D. as second in division, experienced proteins; administrative ability; to $14,000; important eastern pharmaceutical house. (c) **Pharmacologist;** screening; supervise assistant, report to director, pharmacological research; to $8500; midwestern concern. (d) **Chemist;** B.S., M.S., cognizant latest chemical procedures; well-established health laboratory; minimum $6500; eastern resort location. Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

POSITIONS OPEN

All-level LIFE & PHYSICAL SCIENTISTS
For immediate placement as Researchers, Professors, Administrators, Directors, Managers, Executives
write Dr. A. H. Hammond
NATIONAL SCIENTIFIC PERSONNEL BUREAU, Inc.
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